DOE/OR/21548-803
CONTRACT NO. DE-AC05-86OR21548

COMPLETION REPORT FOR THE HYDROGEOLOGICAL FIELD STUDIES IN SUPPORT OF THE QUARRY RESIDUAL OPERABLE UNIT

WELDON SPRING SITE REMEDIAL ACTION PROJECT
WELDON SPRING, MISSOURI

AUGUST 1999 **REV. 0**

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

Prepared by MK-Ferguson Company and Jacobs Engineering Group

MORRISON KNUDSEN CORPORATION MK-FERGUSON GROUP Weldon Spring Site Remedial Action Project Contract No. DE-AC05-86OR21548	
	Rev. No. 0
PLAN TITLE: Completion Report for the Hydrogeological Field Studies in Support of the Quarry Residual Operable Unit	

APPROVALS

Quarry Residuals Operable Unit Coordinator	8-6-99 Date
Quarry/VP Project Manager	6 Aug 99 Date
Compliance Manager	8-9-99 Date
Engineering Manager	8-9-99 Date
Project Quality Manager for PDC	8/11/99 Date
Deputy Project Director	8/11/99 Date

DOE/OR/21548-803

Weldon Spring Site Remedial Action Project

Completion Report for the Hydrogeological Field Studies in Support of the Quarry Residual Operable Unit

Revision 0

August 1999

Prepared by

MK-FERGUSON COMPANY
and
JACOBS ENGINEERING GROUP
7295 Highway 94 South
St. Charles, Missouri 63304

for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

8-13-99

ABSTRACT

The *Record of Decision for Remedial Action for the Quarry Residuals Operable Unit of the Weldon Spring Site* outlines the performance of field studies to support the decision for long-term monitoring of groundwater. The purpose of these studies is to provide design information for the interceptor trench field study and to supplement the current conceptual fate and transport model for this area. This report summarizes the hydrogeological field studies performed as part of these field studies.

TABLE OF CONTENTS

SECTION **PAGE**

1. INTRODUCTION 1
1.1 Purpose and Scope 1
2. FIELD ACTIVITIES 3
2.1 Drilling and Sampling 3
2.2 Packer Testing 5
2.3 Temporary Well Installation and Development 5
2.4 Borehole and Temporary Well Abandonment 6
2.5 Hydraulic Conductivity Testing 7
2.6 Environmental Safety and Health 7
2.7 Waste Management 8
3. HYDROGEOLOGIC DATA ANALYSIS 9
3.1 Geologic Characterization 9
3.1.1 Alluvium 9
3.1.2 Bedrock 12
3.2 Hydraulic Conductivity Testing 12
3.2.1 Slug Testing 15
3.2.2 Packer Testing 16
3.3 Geotechnical Testing 17
4. CHARACTERIZATION RESULTS 18
4.1 Variation in Aquifer Parameters in the Fine-Grained Materials 18
4.2 Interceptor Trench Construction 18
5. REFERENCES 21

APPENDIXES

A Geologic Logs
B Slug Testing Data Sheets
C Packer Test Field Sheets and Calculations
D Geotechnical Testing Data Sheets

LIST OF FIGURES

NUMBER **PAGE**

Figure 2-1 Borehole Locations 4
Figure 3-1 Cross Section A-A 10
Figure 3-2 Cross Section B-B 11
Figure 3-3 Alluvium Thickness 13
Figure 3-4 Bedrock Topography 14
Figure 4-1 Location of Test Interceptor Trench 20

LIST OF TABLES

NUMBER **PAGE**

Table 2-1 Borehole Summary Table 3
Table 2-2 Temporary Well Installation and Development Summary 6
Table 3-1 Summary of Slug Testing Results 15
Table 3-2 Summary of Packer Testing Results 16
Table 3-3 Summary of Geotechnical Testing Results 17

1. INTRODUCTION

The selected remedy in the *Record of Decision for Remedial Action for the Quarry Residuals Operable Unit at the Weldon Spring Site* (Ref. 1) outlines the performance of two field studies to support the decision for long-term monitoring of groundwater. These field studies include installation and operation of an interceptor trench and hydrogeologic and geochemical sampling in the area of uranium impact. These studies are being performed to (1) verify the effectiveness of uranium removal by groundwater extraction methods and (2) provide additional data to support the contaminant fate and transport conceptual models for the quarry area.

1.1 Purpose and Scope

This completion report summarizes the hydrogeological sampling performed as part of these field studies.

The purpose of the hydrogeological sampling was to:

- Provide design constraints or limits to determine the optimal location of the interceptor trench.
- Supplement the current conceptual model regarding the site hydrogeological characteristics that control the effectiveness of the removal of uranium from groundwater.

The primary objectives of the hydrogeological sampling program, as outlined in the *Hydrogeological Characterization Sampling Plan in Support of the QROU Field Studies* (Ref. 2) were to:

- Further define the lateral and vertical distribution of the various fine-grained materials north of the slough.
- Determine the grain-size distribution of the material types comprising the fine-grained alluvium north of the slough.
- Determine the variation in aquifer parameters due to the heterogeneity of the fine-grained alluvium.
- Provide a detailed description of the Decorah Group beneath the fine-grained materials north of the slough.

- Refine the bedrock topography in the area where the interceptor trench will be constructed.

2. FIELD ACTIVITIES

Field studies were conducted in the area immediately south of the quarry and north of the Femme Osage Slough from January 14 through February 6, 1999. Drilling and well installation was performed by Geotechnology, Inc. under Work Package 476, Task 13. During that period, 12 boreholes (Figure 2-1) were drilled and sampled, and eight temporary wells were installed, developed, tested, and abandoned. A detailed description of the field activities, as well as a summary of testing methods and data analyses, are presented in technical memorandum 3840TM-3033-00, *WSSRAP Quarry Residuals Operable Unit Hydrogeologic Characterization Report* (Ref. 3).

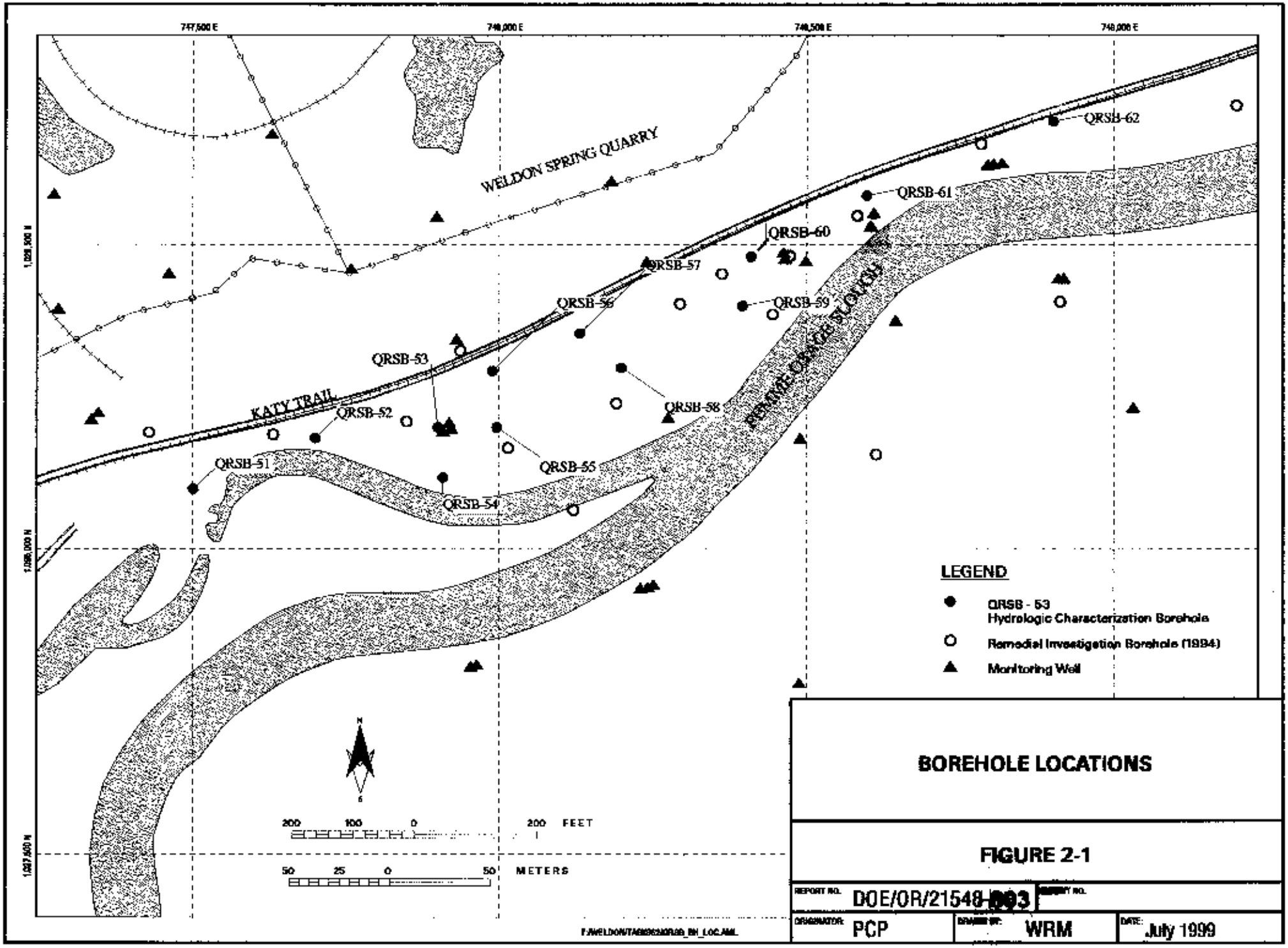
2.1 Drilling and Sampling

The boreholes were drilled and sampled at locations summarized in Table 2-1. These locations vary from those presented in the *Sampling Plan* (Ref. 2), as follows:

- Boreholes QRSB-51, QRSB-57, and QRSB-60 were moved from locations on the north side of the Katy Trail to the south side of the trail to drill into a thicker section of saturated alluvium.
- Borehole QRSB-62 was repositioned south of the Katy Trail and east of its original location to provide better alluvium data and fill in a gap between previous borings.
- Borehole QRSB-54 was moved south of its original location and was designated an alluvial boring in which a temporary well was installed.
- Borehole QRSB-56 was designated as a replacement bedrock borehole for QRSB-54 and core-drilled to the Decorah Group-Plattin Limestone contact.

Table 2-1 Borehole Summary Table

BOREHOLE ID	NORTHING	EASTING	GROUND ELEVATION	TOTAL DEPTH (ft)
QRSB-51	1028099.1	747500.6	457.64	25.0
QRSB-52	1028182.2	747700.0	458.76	14.0
QRSB-53	1028198.8	747899.3	458.20	18.7
QRSB-54	1028117.2	747907.7	456.12	33.5
QRSB-55	1028199.6	747995.5	456.34	27.0
QRSB-56	1028091.9	747988.4	464.12	35.0
QRSB-57	1028354.0	748131.3	456.58	29.8
QRSB-58	1028297.5	748197.9	455.26	26.3
QRSB-59	1028398.6	748396.0	454.78	22.5
QRSB-60	1028479.9	748409.8	455.41	30.4
QRSB-61	1028580.0	748597.5	459.09	13.5
QRSB-62	1028702.4	748901.0	462.96	16.0


747,500 E
748,000 E
748,500 E
749,000 E
WELDON SPRING QUARRY
KATY TRAIL
PERIME CREEK SLOUGH
QRSB-51
QRSB-52
QRSB-53
QRSB-54
QRSB-55
QRSB-56
QRSB-57
QRSB-58
QRSB-59
QRSB-60
QRSB-61
QRSB-62
LEGEND
QRSB - 53
Hydrologic Characterization Borehole
Remedial Investigation Borehole (1994)
Monitoring Well
200 100 0 200 FEET
50 25 0 50 METERS
BOREHOLE LOCATIONS
FIGURE 2-1
REPORT NO. DOE/OR/21548-003
ORIGINATOR: PCP
DRAWN BY: WRM
DATE: July 1999

All boreholes were drilled using an all-terrain CME-550 drill rig. Hollow-stem augers with an inside diameter (ID) of 4-1/4 in. and outside diameter (OD) of 7-1/4 in. were used through the unconsolidated materials.

Twelve boreholes were drilled during the field effort. Eight were terminated at the top of rock and four were core-drilled through the Decorah Group to the contact with the Plattin Limestone. QRSB-54, located adjacent to the slough, exhibited heaving sand and drilling had to be terminated before auger refusal at the top of rock. Soil sampling was performed continuously throughout each borehole using a 5-ft CME soil sampler with an OD of 4 in. Soils were described according to Procedure ES&H 4.4.7, *Soil, Rock Core, and Rock Chip Borehole Logging* using the Unified Soil Classification System. Samples of recovered soils were selected by the field geologist for geotechnical testing to determine grain-size distribution and Atterberg Limits in the alluvial sediments.

Core drilling was performed in Boreholes QRSB-51, QRSB-52, QRSB-56, and QRSB-60. Once bedrock was encountered, as indicated by auger and/or sampler refusal, the drilling method was changed to NQ wireline coring. A 10-ft solid core barrel was used to retrieve rock cores. Retrieved core was placed in wooden core boxes for storage and logged in accordance with Procedure ES&H 4.4.7. Coring at each location was continued until the field geologist determined that the contact between the Decorah Group and the Plattin Limestone had been reached.

2.2 Packer Testing

During the drilling of the four bedrock core holes, pressure testing (packer testing) was performed in accordance with the *Sampling Plan* (Ref. 2). Packer tests were performed at intervals of approximately 10-ft, throughout the length of the boring. A single packer assembly used for this testing and the borehole were pressurized by pumping water directly into the boring. Test pressures and flow rates were measured using a pressure gauge and water meter, respectively. Four individual tests of 6 to 10 minute duration were performed at various water pressures. Results from the packer testing are discussed in Section 3.

2.3 Temporary Well Installation and Development

Temporary wells were installed in the eight boreholes advanced only in the fine-grained alluvium. The temporary wells were constructed using 5 ft to 10 ft of 2-in. Schedule 40 polyvinyl chloride (PVC) screen (0.010-in. slot) with a 3.5-in. OD outer screen. The annulus between the two screens was field-packed with 10-20 mesh silica sand. A threaded cap covered the top and bottom of the annulus between the screens. A 2-in. blank riser was installed from the screen to a few feet above the ground surface. No additional filter pack or other annulus materials were placed in the temporary wells. A shale trap was attached to the PVC riser at

approximately 1.5 ft below the ground surface and bentonite chips were emplaced to the ground surface and hydrated with potable water to create a surface seal. A locking cap was placed on the PVC riser.

All temporary wells were developed to minimize the effects of borehole wall smearing during drilling, and to facilitate hydraulic conductivity testing in the wells. Wells were developed after a minimum of 24 hours had elapsed to allow for setting of the bentonite seals. Development was accomplished by initially surging the well with a hand-held PVC surge block unit. This surging action breaks down any skin effects of the borehole caused by the drilling process. After completion of surging, the well was pumped using a peristaltic pump to remove sediment-laden groundwater. Volumes removed from the wells ranged from 6 to 10 gallons. Wells installed in boreholes QRSB-52, QRSB-55, QRSB-61, and QRSB-62 exhibited low recharge rates during development and were pumped several times until the desired amount of water was removed. A summary of the construction data for the temporary wells, static water levels measured after development, and observations made during development is provided in Table 2-2.

Table 2-2 Temporary Well Installation and Development Summary

Well ID	Top of Casing Elevation (ft MSL)	Total Depth (ft)	Screened Interval (ft BGS)	Static Water Level (ft BGS)	Comments
QRSB-52	460.96	14.0	8.4 – 13.4	7.9	Pumped dry at < 1 gpm Slow recharge
QRSB-53	460.70	18.7	7.5 – 17.8	7.0	Sustained at approx. 1 gpm Turbid water
QRSB-54	457.32	33.5	23.8 – 28.8	8.6	Sustained at approx. ¾ gpm Slightly cloudy water
QRSB-55	458.04	27.0	21.4 – 26.4	6.6	Pumped dry at 1 gpm Slow recharge Slightly cloudy water
QRSB-58	457.16	26.3	20.4 – 25.4	6.4	Sustained at approx. 1 gpm Slightly cloudy water
QRSB-59	456.78	22.5	10.7 – 21.0	4.6	Sustained at approx. 1 gpm Slightly cloudy water
QRSB-61	461.09	13.5	8.0 – 13.0	7.8	Pumped dry at 1 gpm Slow recharge
QRSB-62	464.46	16.0	10.4 – 15.4	11.6	Slow recharge Very turbid water

MSL – mean sea level
BGS – below ground surface

2.4 Borehole and Temporary Well Abandonment

Each borehole and temporary well was abandoned according to Missouri well construction rules (10 CSR 23) and the specifications outlined in Work Package 476, Task 13. Temporary well screens and casing were removed from the boreholes, which were grouted to the

surface through a tremie pipe using high solids bentonite grout. Boreholes advanced into the bedrock were also grouted from the bottom using a tremie pipe.

2.5 Hydraulic Conductivity Testing

Single well hydraulic conductivity tests (slug tests) were conducted during January and February 1999 in the eight temporary wells and in an existing monitoring well, MW-1014. All nine wells were completed in the saturated portion of the shallow aquifer north of the slough. A minimum of three slug tests was performed at each location, in accordance with the *Sampling Plan* (Ref. 2).

Slug tests were performed using a solid PVC slug. During testing, a low initial displacement of water was observed in temporary wells QRSB-52, QRSB-53, QRSB-61, and QRSB-62. To achieve adequate displacement, a large volume of water was introduced into these wells. These four temporary wells were installed in clayey materials and the formation did not collapse against the well screen as it did in the other temporary wells. Due to the lack of collapse, the water was displaced into the annulus between the borehole and the well screen; therefore, initial test results were not representative of the aquifer matrix. A series of five slug tests was performed at MW-1014 using both the solid slug and various volumes of water to evaluate potential differences in results based on methodology and also for comparison with test results at nearby QRSB-53.

2.6 Environmental Safety and Health

The drilling was performed in accordance with the subcontractor's Safe Work Plan, under the authority of the *Weldon Spring Site Health and Safety Plan* (Ref. 4). Safety Department representatives performed an initial safety inspection of the subcontractor's drill rig and provided coverage throughout the fieldwork. No safety-related incidents or accidents occurred during this investigation.

Representatives of the Environmental Safety and Health (ES&H) Department provided continuous coverage during the fieldwork. Work was performed in Level D personal protective equipment consisting of coveralls, steel-toed boots, work gloves, safety glasses, and hard hats. In addition, latex gloves were worn when handling soil and rock samples, and drilling and sampling tools. Non-drilling personnel wore fluorescent safety vests. Soil and rock samples retrieved during drilling were surveyed by ES&H personnel for beta and gamma activity using a Ludlum 44-9 Geiger-Mueller detector, as outlined in the *Sampling Plan* (Ref. 2). None of the samples measured above background during this screening.

2.7 Waste Management

As outlined in the *Sampling Plan* (Ref. 2), soil cuttings and water generated from drilling, temporary well installation, and well development were collected and containerized. The soil cuttings were placed in lined 55-gallon drums with secured lids. Water generated from drilling or well development was also collected in 55-gallon drums with secured lids. At the end of the field work, the drilling subcontractor transported the soil and water over the quarry haul road to the chemical plant for disposal.

3. HYDROGEOLOGIC DATA ANALYSIS

3.1 Geologic Characterization

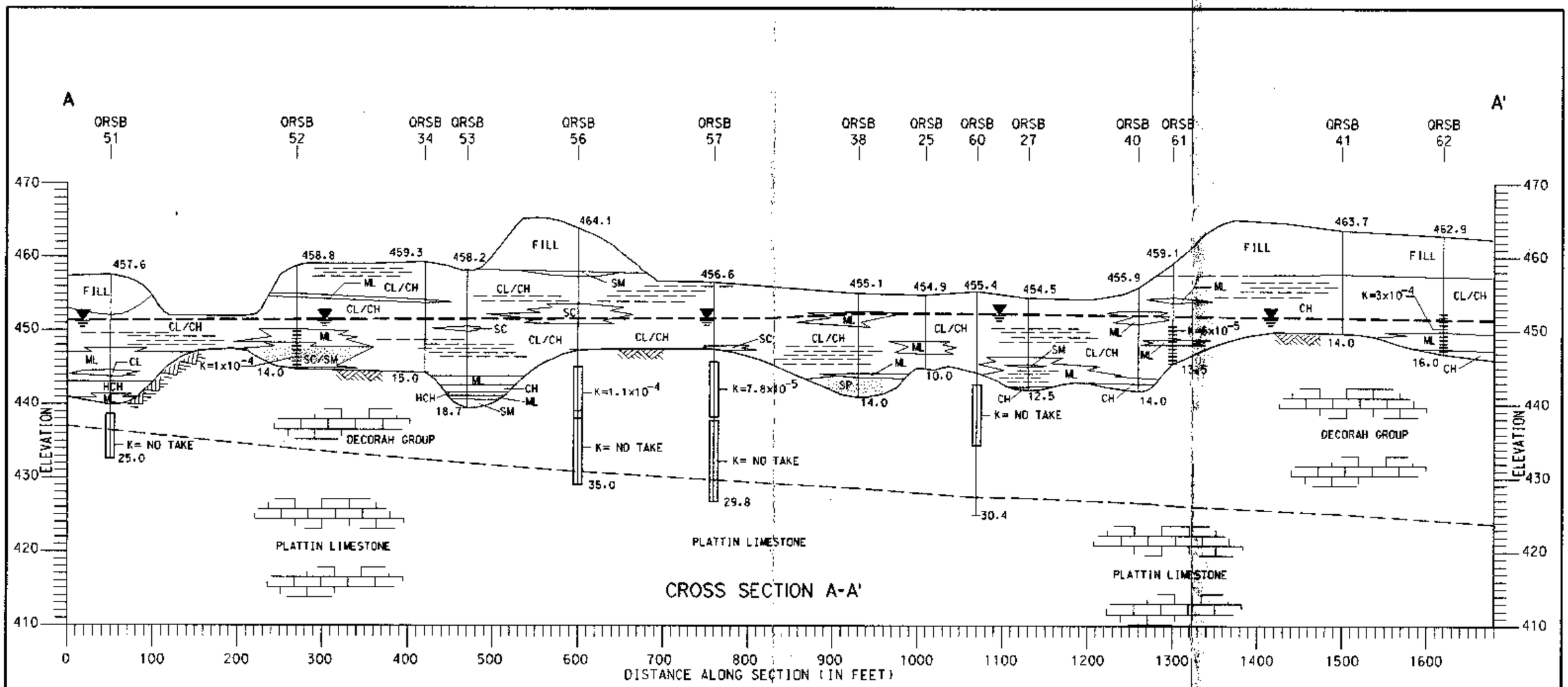
Geologic information obtained from this study includes lithologic and geologic descriptions, fracture densities, mineralogy, secondary mineralogy, organic content, identification of formation contacts, unit thicknesses, and depths to bedrock. Analysis of this data focused on identifying correlatable units within the fine-grained alluvium, identifying zones of preferential groundwater movement in both the fine-grained alluvium and bedrock, and identifying secondary mineralogy of the aquifer matrix. Geologic logs for these borings are contained in Appendix A.

3.1.1 Alluvium

Twelve boreholes (Figure 2-1) were advanced through the alluvial materials north of the slough. Sediment types encountered were similar to those observed during previous investigations. As depicted on the cross-sections (Figures 3-1 and 3-2), alluvial sediments encountered in the borings were primarily fine-grained, including high and low plasticity clays and silts. These cross-sections were constructed using the data obtained from this study and information from previous investigations. At locations closer to the slough, silty and clayey fine- to medium-grained sands were encountered at the base of the alluvium. Sampling of the alluvium north of the slough indicates a broad correlation of sediments across the area, although discrete units or beds were generally not identified and correlated between boreholes. This was not unexpected given the complex depositional patterns of the Femme Osage Creek and the Missouri River.

Nearer the quarry bluff very little silt or sand was encountered (Figure 3-1). Sands that are present appear to be isolated, near-channel, or channel deposits that include a significant amount of fines (silt and clay). At the east end of the section (QRSB-52), near the Femme Osage Slough, a fining upward sequence is observed going from gravelly sand at the base to silty sand, then to clay silts, to low to high plasticity clays. This sequence indicates a transition from an active channel to an overbank-floodplain depositional environment. At Borehole QRSB-38, sand was encountered near the top of bedrock, with an upward fining sequence also noted. The sand deposit appears to be coincident with a bedrock low at this location.

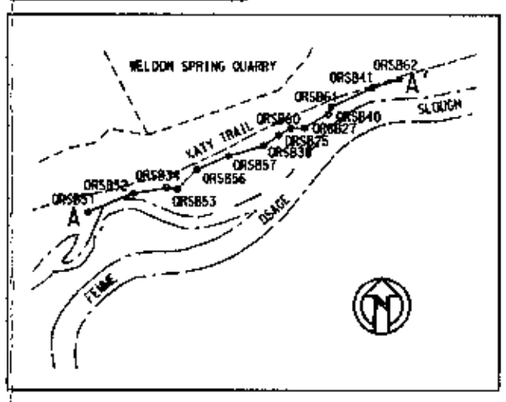
Very high plasticity clay was encountered in QRSB-51 and QRSB-53 near the base of the alluvium. This clay is identified as "HCH" on the cross-section (Figure 3-1). This unit was the most distinct and correlatable unit observed in samples from the study area. This unit exhibits very high plasticity as indicated by its high degree of moldability. In samples, this clay would commonly exhibit conchodial breaks with concentric sand pockets and organics, including coalified wood.



LEGEND

$K=2\times10^{-4}$	SCREENED INTERVAL OF TEMPORARY WELL WITH SLUG TEST RESULT (cm/sec)
$K=1\times10^{-4}$	PACKER TESTING INTERVAL WITH RESULT (cm/sec)
33.5	TOTAL BOREHOLE DEPTH
	10X VERTICAL EXAGGERATION
▼	STATIC WATER LEVEL IN TEMPORARY WELL
CL	LOW PLASTICITY CLAY
CH	HIGH PLASTICITY CLAY
HCH	VERY HIGH PLASTICITY CLAY
ML	SILT
SM	SILTY SAND
SC	CLAYEY SAND
SP	POORLY GRADED SAND

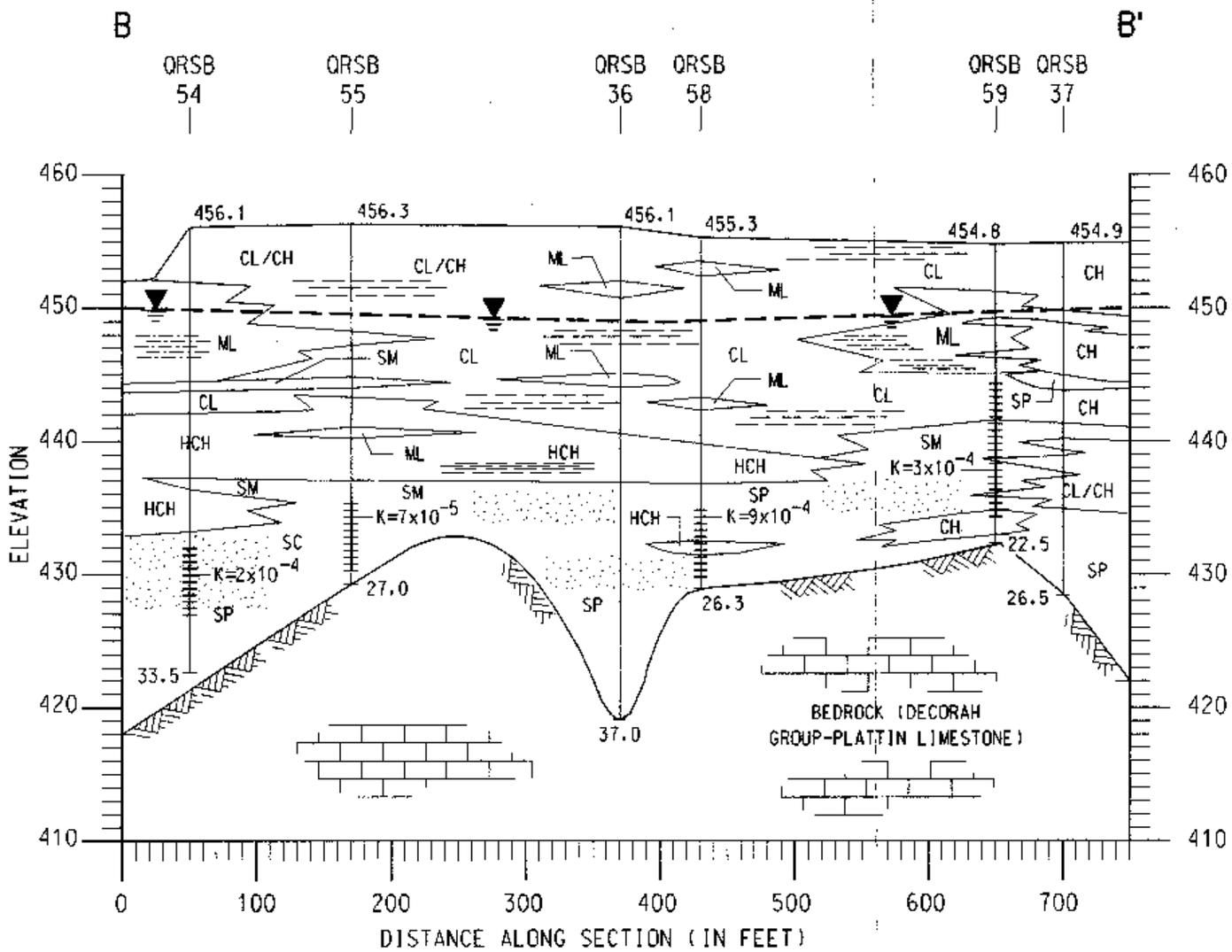
LOCATION MAP



CROSS-SECTION A-A'

FIGURE 3-1

REPORT NO: DOE/OR/21548-803	DRAWING NO: WO3840\PPGEO.DGN	
ORIGINATOR: P PARSONS	DRAWING BY: R PARSONS	DATE: JULY 1999



CROSS SECTION B-B'

LEGEND

K=2x10^-4 — SCREENED INTERVAL OF TEMPORARY WELL WITH SLUG TEST RESULT (cm/sec)

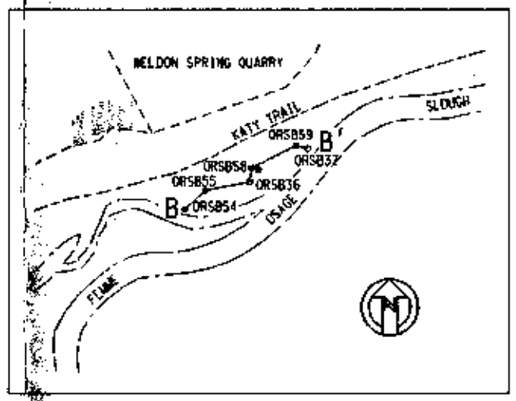
33.5 — TOTAL BOREHOLE DEPTH

STATIC WATER LEVEL IN TEMPORARY WELL

CL LOW PLASTICITY CLAY
CH HIGH PLASTICITY CLAY
HCH VERY HIGH PLASTICITY CLAY
ML SILT
SM SILTY SAND
SC CLAYEY SAND
SP POORLY GRADED SAND

10X VERTICAL EXAGGERATION

LOCATION MAP



CROSS-SECTION B-B'

FIGURE 3-2

REPORT NO: DOE/OR/21548-603	DRAWING NO: W03840\PPGEO.DGN	
ORIGINATOR: P PARSONS	DRAWING BY: R PARSONS	DATE: JULY 1999

Organic material in the form of roots, twigs, wood chips, leaves, and large grass stalks were very common in all soil types, including sand sampled in the study area. In the upper, more oxidized zones of the alluvium, this material was commonly replaced with limonite and hematite (iron oxides). A distinct, geochemical reduction or anaerobic contact was observed in many of the borings and was indicated by a color change in the alluvial materials from brown to gray. Below this oxidation and reduction interface, much of the organic material did not appear to be decomposed, but was commonly coalified (carbon-like). This condition was more pronounced in the boreholes closer to the slough.

An increase in sand thickness was noted closer to the slough as the bedrock surface slopes southward (Figure 3-3). Fine-grained sands are common in the lower portion of boreholes in this area, with most exhibiting a significant amount of silt and/or clay content. There are some areas, such as at QRSB-59, having relatively well-graded medium- to coarse-grained sands. The HCH clay is correlatable between three of the borings on this section.

The thickness of the alluvium in the area north of the slough ranges from less than 10 ft near the Katy Trail up to 35 ft at the north edge of the slough (Figure 3-4). Thicker sequences closer to the Katy Trail are the result of sediment filling in channels or lows in the bedrock surface.

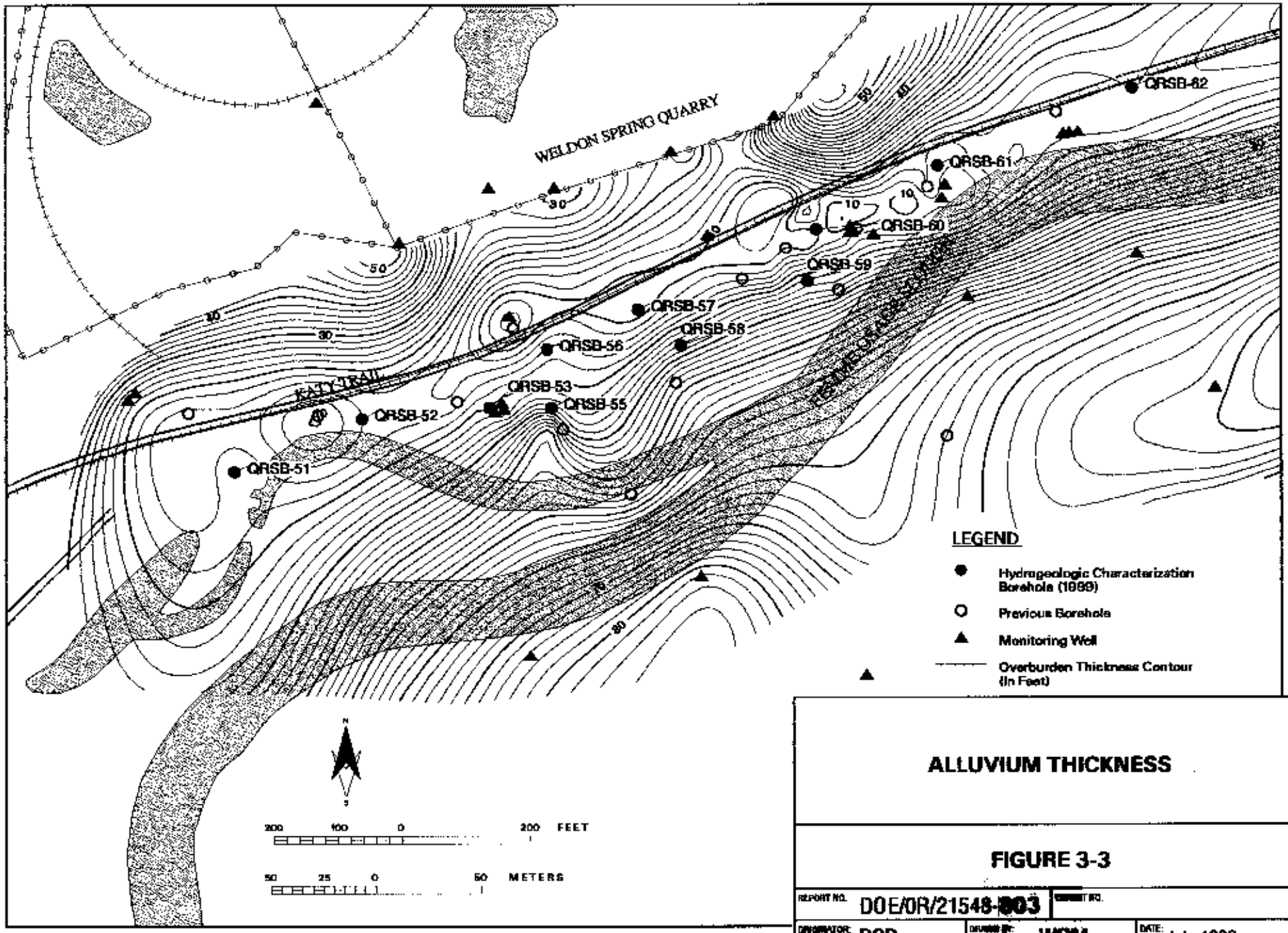
3.1.2 Bedrock

Four of the eight boreholes (QRSB-51, QRSB-56, QRSB-57, and QRSB-60) were advanced through the underlying Decorah Group into the Plattin Limestone. Bedrock encountered during this investigation was similar to that observed during previous investigations. The thickness of the Decorah Group ranges from 3.9 ft to 18.3 ft in the area north of the slough. These thicknesses are less than typical due to erosion of this unit in the Missouri River floodplain.

Boreholes drilled during this investigation provided data to refine the quarry bedrock surface map (Figure 3-4). Bedrock relief exceeds 40 ft across the area from the Katy Trail to the slough. The surface of the bedrock is relatively uneven and undulating, likely due to weathering of the limestone and channeling by the Missouri River and the Femme Osage Creek.

3.2 Hydraulic Conductivity Testing

Hydraulic conductivity testing was performed in both the fine-grained alluvium and bedrock for this investigation. Data obtained from packer tests and slug tests were used to calculate hydraulic conductivity ranges for these units.

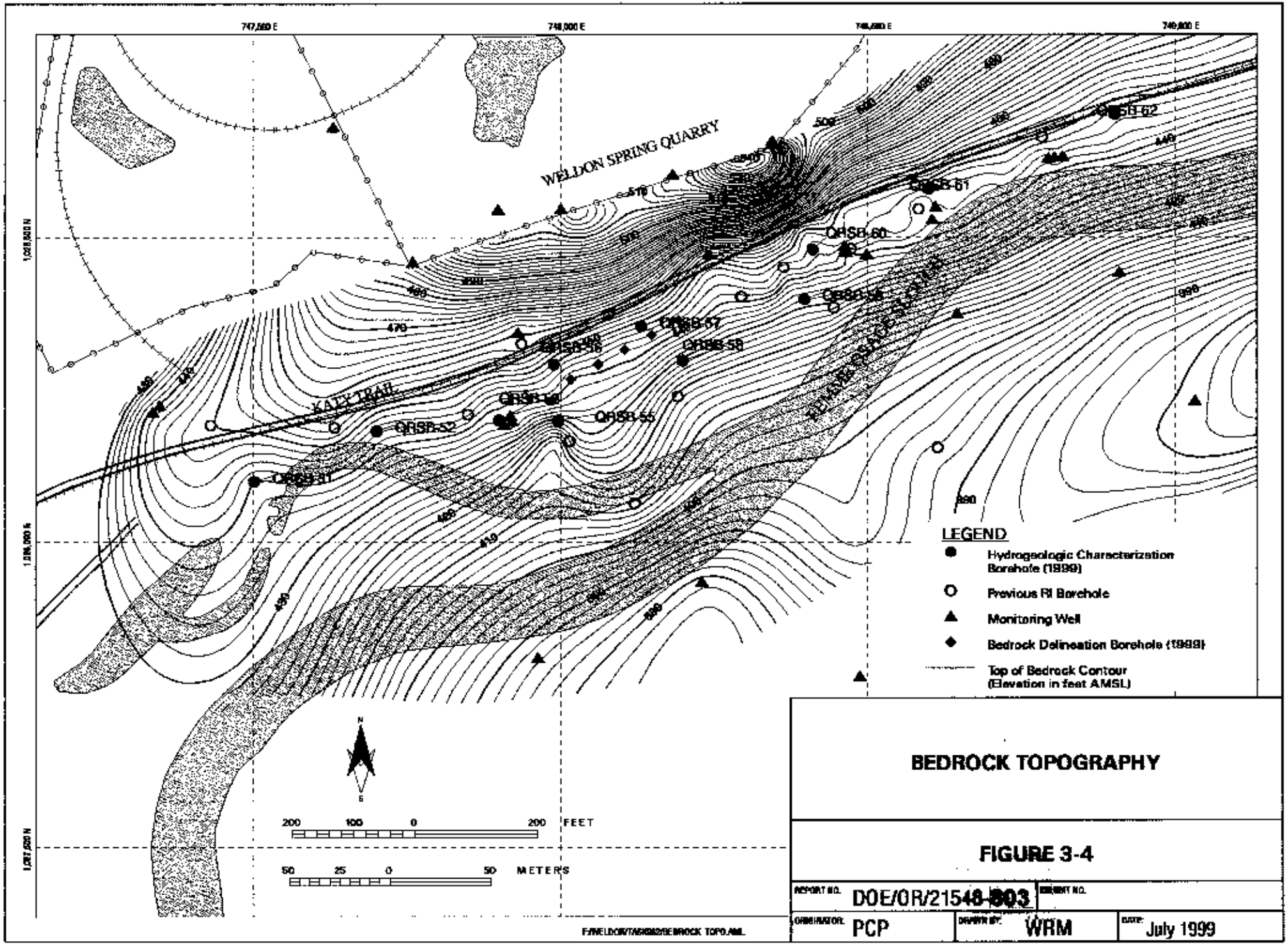


ALLUVIUM THICKNESS

FIGURE 3-3

REPORT NO. DOE/OR/21548-003			
ORIGINATOR: PCP	DRAWN BY: WRM	DATE: July 1999	

F:\WELDON\TAGIS\82\ALLUV_THICK.AML


WELDON SPRING QUARRY
KATY TRAIL
QRSB-52
QRSB-55
QRSB-57
QRSB-58
QRSB-60
QRSB-61
QRSB-62
LEGEND
Hydrogeologic Characterization Borehole (1999)
Previous RI Borehole
Monitoring Well
Bedrock Delineation Borehole (1999)
Top of Bedrock Contour (Elevation in feet AMSL)
N
S
200 100 0 200 FEET
50 25 0 50 METERS
BEDROCK TOPOGRAPHY
FIGURE 3-4
REPORT NO. DOE/OR/21548-803
DRAWN BY: WRM
DATE: July 1999

3.2.1 Slug Testing

Hydraulic conductivity estimates were based on data analysis using the Bouwer and Rice method (Ref. 5), which is the same methodology used to estimate hydraulic conductivity during previous investigations. A summary of the results is presented in Table 3-1. Data plots for each well are presented in Appendix B.

Table 3-1 Summary of Slug Testing Results

WELL ID	TEST INTERVAL	TEST TYPE	K (cm/s)	AVERAGE K (cm/s)	COMMENTS
QRSB-52	8.4 – 13.4	Falling	1×10^{-4}	1×10^{-4}	None
QRSB-53	7.5 – 17.8	Falling	5×10^{-4}	5×10^{-4}	Boring is located 10.89 ft. from MW-1014
QRSB-54	23.8 – 28.8	Falling	2×10^{-4}	2×10^{-4}	Consistent test results with strong log-linear data trend.
		Rising	2×10^{-4}		
		Falling	2×10^{-4}		
		Rising	2×10^{-4}		
QRSB-55	21.4 – 26.4	Falling	8×10^{-5}	7×10^{-5}	Last test considered most representative for this well.
		Rising	Not Analyzed		
		Falling	9×10^{-5}		
		Rising	6×10^{-5}		
QRSB-58	20.4 – 25.4	Falling	9×10^{-4}	9×10^{-4}	Consistent test results with strong log-linear data trend.
		Rising	9×10^{-4}		
		Falling	8×10^{-4}		
		Rising	9×10^{-4}		
QRSB-59	10.7 – 21.0	Falling	4×10^{-4}	3×10^{-4}	Falling data in all cases.
		Rising	3×10^{-4}		
		Falling	4×10^{-4}		
		Rising	3×10^{-4}		
QRSB-61	8.0 – 13.0	Falling	6×10^{-5}	6×10^{-5}	None
QRSB-62	10.4 – 15.4	Falling	3×10^{-4}	3×10^{-4}	None
MW-1014	16.0 – 21.0	Falling	7×10^{-3}	6×10^{-3}	Results consistent with previous results. Results between testing methods are consistent.
		Rising	7×10^{-3}		
		Falling	5×10^{-3}		
		Falling	6×10^{-3}		
		Falling	6×10^{-3}		
		Pumping	6.4×10^{-6}	—	None
		Recovery	7.5×10^{-6}	—	None

The slug test-derived hydraulic conductivity estimates are generally consistent with those for previous aquifer tests (Ref. 6). Heterogeneous conditions are indicated by the difference of slightly more than an order of magnitude between MW-1014 and QRSB-53, which are located approximately 10 ft apart. Review of the borehole logs for these two wells indicates slightly deeper bedrock containing gravelly silt in MW-1014, which is not present in QRSB-53. The presence of this coarser-grained material may account for the higher hydraulic conductivity estimate in MW-1014.

3.2.2 Packer Testing

Packer test results from the four boreholes cored into the bedrock indicate generally low hydraulic conductivity (10^{-4} to 10^{-5}). The results from the testing are provided in Table 3-2 along with the stratigraphic unit for each test. Field sheets and calculations are included in Appendix C.

Table 3-2 Summary of Packer Testing Results

TEST INTERVAL	TEST NUMBER	TEST PRESSURE (psi)	K (cm/s)	AVERAGE K (cm/s)	STRATIGRAPHIC UNIT
QRSB – 51					
	Depth to Bedrock = 17.5 ft.		Static Water Level = 6.5 ft.		
19.0 – 25.0	1	6	No water take at any pressure during testing.	Not calculated	Lower Decorah Group/Upper Plattin Limestone
	2	12			
	3	17			
	4	6			
QRSB – 56					
	Depth to Bedrock = 16.5 ft.		Static Water Level = 12.7 ft.		
19.0 – 26.0	1	6	No take	1.1×10^{-4}	Upper Decorah Group
	2	12	1.1×10^{-4}		
	3	17	1.2×10^{-4}		
	4	6	8.0×10^{-5}		
25.0 – 35.0	1	10	No water take at any pressure during testing.	Not calculated	Lower Decorah Group (minor Upper Plattin Limestone)
	2	15			
	3	20			
	4	10			
QRSB – 57					
	Depth to Bedrock = 8.5 ft.		Static Water Level = 5.7 ft.		
10.0 – 17.8	1	4	No take	7.8 x 10-5	Upper Decorah Group
	2	6	No take		
	3	9	8.6 x 10-5		
	4	4	7.1 x 10-5		
18.0 – 29.8	1	6	No water take at any pressure during testing.	Not calculated	Lower Decorah Group (minor Upper Plattin Limestone)
	2	12			
	3	17			
	4	6			
QRSB – 60					
	Depth to Bedrock = 10.7 ft.		Static Water Level 3.5 ft.		
12.5 – 20.4	1	4	No water take at any pressure during testing.	Not calculated	Upper Decorah Group
	2	8			
	3	13			
	4	4			

Results from the packer testing generally agree with results from previous testing in these units. The upper portion (approximately 7 ft.) of the Decorah Group was the only section of bedrock that took water during testing due to the larger degree of weathering and fracturing in this section of the unit. The lower portion of the Decorah Group and the portion of the Plattin Limestone that was tested in each hole did not take any water during testing, indicating a very low hydraulic conductivity for this unit.

3.3 Geotechnical Testing

Geotechnical information obtained from sediments from each of the boring includes grain-size distributions and Atterberg limits (liquid limit, plastic limit, and plasticity index). The determination of Atterberg limits was not originally outlined in the *Sampling Plan* (Ref. 2), but was performed to provide better classification of the material types encountered in the interceptor trench area. Data sheets for this testing is contained in Appendix D.

Soil testing was performed on samples collected from eight of the boreholes at intervals that represented both discrete zones and composited intervals. The number and type of tests performed on the materials from each area depended primarily on the variability of the soils encountered. The samples were tested under the supervision of the Project Quality department. A summary of the test results form each boring is provided in Table 3-3.

Table 3-3 Summary of Geotechnical Testing Results

Borehole	Interval (ft. BGS)	Percent Passing Standard Sieve Size [1]				Atterberg Limits [2]			
		1"	#4	#100	#200	Liquid Limit	Plastic Limi	Plasticity Index	USCS Classification
QRSB-52	8.6-14.0	100	98	92	7	NA	NA	NA	NA
QRSB-53	3.6-5.6	100	100	100	98	54	23	31	CH
QRSB-55	8.0-11.3	100	100	73	82	28	17	11	CL
	15.4-19.0	100	100	100	98	80	31	49	CH
	19.0-26.2	100	100	50	31	NA	NA	NA	NA
QRSB-56	10.5-13.0	100	100	64	49	NA	NA	NA	NA
	13.0-15.5	100	100	82	64	29	20	9	CL
QRSB-57	5.0-8.3	100	100	89	79	32	19	13	CL
QRSB-58	9.5-13.2	100	100	99	96	NA	NA	NA	NA
	18.2-22.9	100	100	15	13	NA	NA	NA	NA
	23.6-26.0	100	100	31	6	NA	NA	NA	NA
QRSB-59	10.3-13.3	100	100	90	76	35	22	13	CL
	18.3-20.3	100	100	27	17	NA	NA	NA	NA
QRSB-60	3.2-5.7	88	85	77	74	36	21	15	CL
	8.4-10.4	100	100	98	95	56	23	33	CH

Note: 1 Determined in accordance with ASTM D422
2 Determined in accordance with ASTM D4318
BGS below ground surface
NA Not analyzed

4. CHARACTERIZATION RESULTS

4.1 Variation in Aquifer Parameters in the Fine-Grained Materials

The distribution of sediments in the area north of the slough suggests a change from a higher energy depositional environment to an overbank and floodplain environment. The occurrence of coarser-grained materials increases with distance from the quarry bluff. Nearer the bluff, sands that are present are noncontinuous with significant fines content.

The thickness of the alluvial materials north of the slough range from approximately 6 ft to 50 ft with thickness increasing to the south. This increasing thickness is due to the eroded sloping bedrock surface. The thickness of the coarser-grained alluvium (silt and sand) also increases with distance from the bluff. Thicknesses up to 15 ft have been logged in this area.

Differing grain sizes of the alluvial sediments do not appear to have a significant effect the hydraulic conductivity test results. The highest measured hydraulic conductivity for the temporary wells was in QRSB-58 screened in a fine- to medium-grained sand with an estimated hydraulic conductivity of 9×10^{-4} cm/s. The lowest value was in QRSB-61 at 6×10^{-5} cm/s, which was screened in high plasticity clay. Review of the grain-size distributions versus the measured hydraulic conductivity in several wells supports the slug test results. The variation of hydraulic conductivity of the aquifer materials ranges from 7×10^{-5} cm/s for predominantly clay materials to 9×10^{-4} cm/s for predominantly sand materials. This relatively low difference in hydraulic conductivities may be due to (1) the non-continuous distribution of the coarser grained materials in the alluvium north of the slough or (2) the presence of finer grained materials (silt and clay) within the sand matrix. It is possible that the effects of drilling in the unconsolidated materials may result in an underestimation of the hydraulic conductivity due to smearing of the clays on the boring wall.

4.2 Interceptor Trench Construction

The siting criteria for the interceptor trench require that it be constructed to intersect a representative cross section of the differing alluvial materials present north of the slough and that it be optimally located to extract groundwater in areas with high uranium contamination (Ref. 7). Specific criteria used for siting the interceptor trench are:

1. Bound hydraulic variations present north of the slough.

2. Bound contaminant variation present north of the slough.

3. Extract groundwater over the full thickness of the alluvial materials.

4. Prevent dewatering of the slough and extraction of unnecessarily large volumes of water that are not impacted by uranium from the quarry.

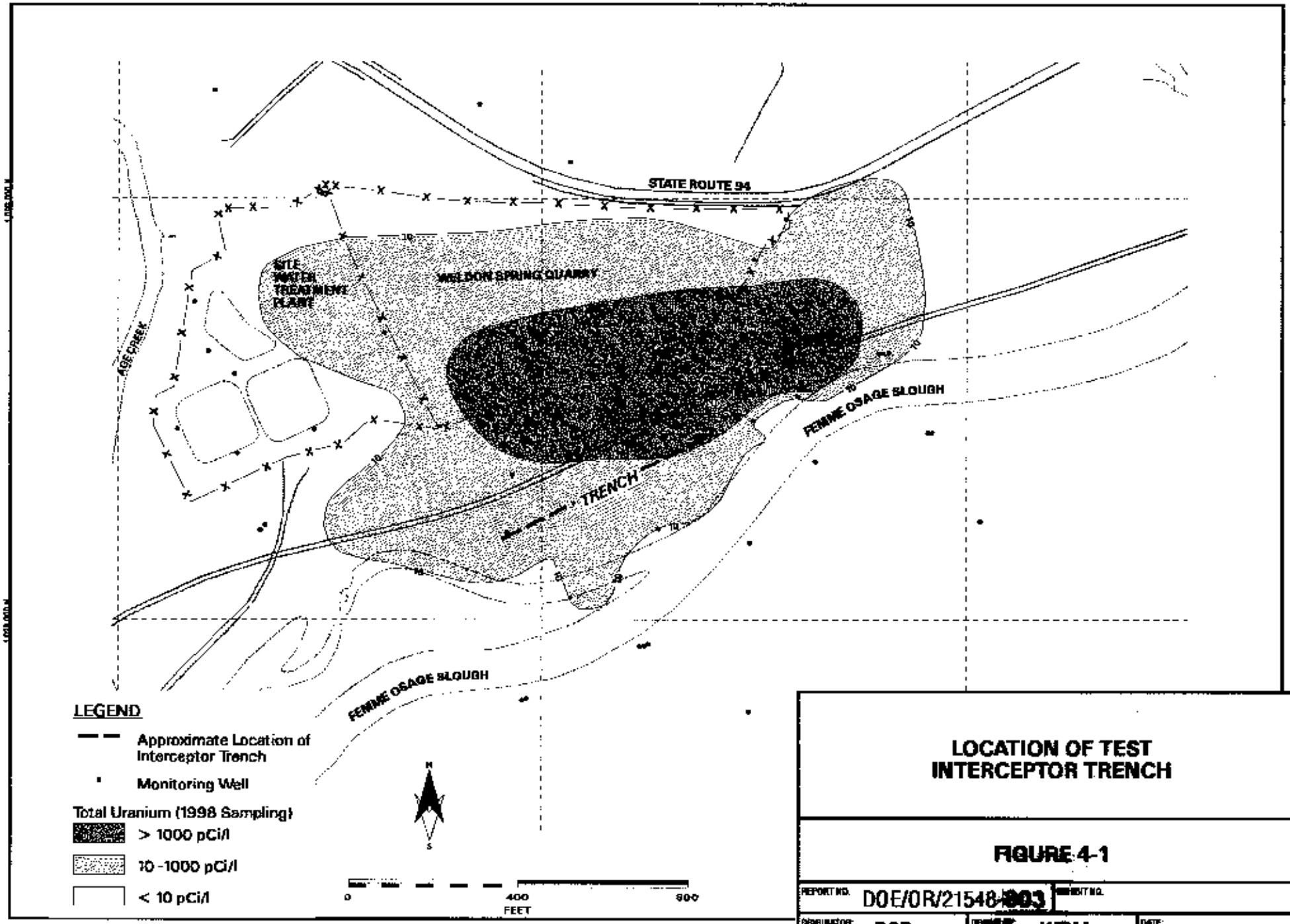
The interceptor trench will be located in the alluvial aquifer south of the Katy Trail and north of the slough and will be approximately 550 ft in length (Figure 4-1). The trench will be constructed through the entire thickness of the alluvial materials. The orientation of the trench will be perpendicular to the general groundwater flow direction.

Cross-sections A-A' and B-B' (Figure 3-1 and 3-2, respectively) indicate that if the interceptor trench were located on either end of the cross section A-A' or anywhere along cross-section B-B', the trench would intersect each of the various fine-grained materials present north of the slough. According to the cross-section A-A', coarser materials are present at the western and eastern edges of the area north of the slough. These locations coincide with bedrock lows, which typically contain more silt and sand. Locating the trench at the center of cross-section A-A' would result in intersecting predominantly clay and silty clay materials.

Location of the trench to the south would intersect coarser-grained materials that are likely connected with more transmissive materials south of the slough (Figure 3-2). This could result in extracting unnecessarily large volumes of groundwater exhibiting lower levels of uranium. Location to the south could also increase the probability of water from the slough being captured by the interceptor trench.

Based on the interpretation of the field data, the most optimal location for the interceptor trench is on the western side of the area north of the slough (Figure 4-1). Locating the trench in the area would meet Criteria 1 and 4. Location of the trench on the eastern side of the area north of the slough could increase the likelihood of intersecting surface water from the slough, therefore failing Criteria 4.

The bedrock topography does not have a controlling factor on the location of the trench, but it does have an impact on the construction of the trench. Utilizing the low areas in the bedrock as sumps will reduce the necessity for excavating the underlying bedrock.



LOCATION OF TEST INTERCEPTOR TRENCH

FIGURE 4-1

REPORT NO. DOE/OR/21548-803

SUBMITTAL NO.

DRAWN BY: PCP

DRAWN BY: WRM

DATE: July 1999

F:\WELDON\TASK\62\TRENCH_LOC.AML

5. REFERENCES

1. Argonne National Laboratory. *Record of Decision for Remedial Action for the Quarry Residuals Operable Unit at the Weldon Spring Site, Weldon Spring, Missouri.* DOE/OR/21548-725. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. September 1998.

2. MK-Ferguson Company and Jacobs Engineering Group. *Hydrogeologic Characterization Sampling Plan in Support of the QROU Field Studies.* Rev. 0. DOE/OR/21548-764. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. November 1998.

3. WSSRAP Quarry Residuals Operable Unit Hydrogeological Characterization Report, Task 394, Technical Memorandum No. 3840TM-3033-00.

4. MK-Ferguson Company and Jacobs Engineering Group. *Weldon Spring Site Remedial Action Project Health and Safety Plan.* Rev. 5. DOE/OR/21548-511. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. March 1999.

5. Bouwer, H. and R. C. Rice. *A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers With Completely or Partially Penetrating Wells*, Vol. 12, No. 3. U.S. Water Conservation Laboratory, Agricultural Research Service, U.S. Department of Agriculture. Phoenix, AZ. June 1976.

6. MK-Ferguson Company and Jacobs Engineering Group. *Remedial Investigation for the Quarry Residuals Operable Unit of the Weldon Spring Site, Weldon Spring Missouri.* Rev. 2. Final. DOE/OR/21548-587. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. February 1998.

7. MK-Ferguson Company and Jacobs Engineering Group. *Remedial Investigation for the Quarry Residuals Operable Unit of the Weldon Spring Site, Weldon Spring Missouri.* Rev. 2. Final. DOE/OR/21548-587. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. February 1998.

PROCEDURE

ES&H 4.4.7, *Soil Rock Core and Rock Chip Borehole Logging*

APPENDIX A
Geologic Logs

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

GEOLOG-C

HOLE NUMBER	QRSB-51
SHEET 1 OF 1	
NORTH(Y):	1028099.08
EAST (X):	747500.63
TOC ELEVATION	457.84
GROUND ELEVATION	457.84
STICKUP	
HYDR CONDUCTIVITY (cm/sec)	K= .0000x10^{-7} (Packer Test)

WELL STATUS/COMMENTS: CHARACTERIZATION BOREHOLE	LOCATION: QUARRY-NORTH OF SLOUGH
DRILLING CONTRACTOR: GEOTECHNOLOGY, INC.	DRILL RIG MAKE & MODEL: CME-550 ALL TERRAIN
HOLE SIZE & METHOD: 7-1/4" HSA, 3" CME Sampler	ANGLE FROM HORIZONTAL & BEARING: 90
DRILL FLUIDS & ADDITIVES: WATER	CASING TYPE, DEPTH, SIZE: n/a
DATE START: 02-01-99	DATE FINISH: 02-02-99

DEPTH (FT.) FROM GROUND ELEV. TO: BOTTOM OF HOLE (TD): 25.0; BEDROCK: 17.5; WATER LEVELS & DATES

LITHOLOGY BY: Paul Patchin

DEPTH feet	SAMPLE	SAMPLE/RUN Number	PERCENT Recovery	N# or RQD	GRAPHIC LOG	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT	LABORATORY SAMPLES	ELEVATION feet
		CME-1	13/41"			opsoil	0 -9" TOPSOIL, dark brown, loamy, organics, gravel, grass.			
						CL	9" - 5.5' FILL, (Gravelly Clay), approx. 30% limestone gravel (1 to 3"), very dark grayish brown (10YR3/2), roots, straw, organics, moist, firm, FeOx CL.	FILL		455
		CME-2	48/60"							
5						CL CH	5.5 - 6.6' SILTY CLAY, med. to high plasticity, ~10% silt, dark grayish brown (10YR4/2), moist, firm (pp=1.25), minor FeOx mottling, CL/CH.		---Approx. water level through augers at 6.5'	
						CH	6.6 - 10.0' CLAY, very dark grayish brown (10YR3/2), with abundant strong brown (7.5YR4/6), FeOx mottling and FeOx replacement in abundant fibrous wood, firm (pp=1.75), moist, CH.			450
		CME-3	60/60"						QRSB-51-6.6-10 (G,A)	
10						ML	10.0 - 14.3' CLAYEY SILT, dark gray (2.5Y4/1) with slightly less strong brown FeOx mottling as above, almost equal fractions of silt and clay (minor fine sand), moist to wet (in siltiest zones), abund. FeOx, rootlet/wood replacement, clay interbedding (clay bed from 13.0-13.5'), very soft (silty zones) to soft (pp=.5), occas. black carbonaceous (coalified) wood pieces, ML.	MO ALLV.	QRSB-51-10-13 (G,A)	445
		CME-4	42/42"			CL ML				
15						CH	14.3 - 16.2' CLAY, very high plasticity, (modeling clay), very moist, with sand pockets, some organics (leaves, roots), concoidal breakage, very soft (pp<.25), dark gray (N4/1), possible shell fragments (very fine), some coalified wood, CH.			
						ML				440
		RUN-1	18/18"	0		lms	16.2 - 17.5' CLAYEY, SANDY, SILT, color as above, wet, very soft, organics (wood, roots, stalks, leaves), slightly coalified wood, possible pelecypod shells, interbedded sand lenses, large (3.5") gravel at base, ML. Auger Refusal at 17.6 ft (top of rock), switch to NQ wireline coring.	Odg	G=Gradation A=Atterberg Limits	
		RUN-2	12/12"	70						
20		RUN-3	60/60"	90		shl cly lms	17.5 - 25.0' LIMESTONE, with stringer-like shaley partings (hairline to 15mm), lithographic, thinly-bedded, hard, slightly weathered with tan dolomite nodules (very hard) from 20.5-21.5' directly above and below a soft shale bed at 20.9-21.2' and a bentonitic shale (clay-like) bed from 21.2-21.4'. The shale is olive gray (5Y4/1) and the bentonitic clay is light gray (N7) with high porosity. The whispy shale partings look similar to stylolites (may be). (DECORAH GROUP to 21.4' then PLATTIN LIMESTONE)	Opl	~ 3.9'	435
25							Total Depth 25.0'. Backfilled borehole with Hole Plug Bentonite Grout.			430
							Note: Soil color is indexed on the Muncell soil color chart. Rock color is from the GSA rock color chart.			
30							CONSTANT HEAD SINGLE PACKER TEST RESULTS: 19.0 - 25.0 ft. no water take			425
35										

Sample Interval No Sample Taken minimum maximum average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE AND WELL COMPLETION LOG

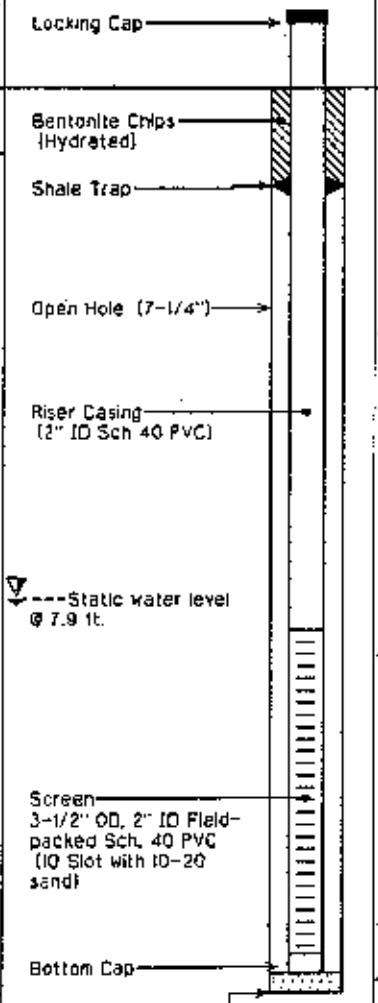
HOLE NUMBER	QRSB-52
SHEET 1 OF 1	
NORTH (Y):	1028182.25
EAST (X):	747699.97
TOC ELEVATION	460.96
GROUND ELEVATION	458.76
STICKUP	2.20
HYDR CONDUCTIVITY (cm/sec) K= 1x10^{-4} (Slug Test)	

WELL STATUS/COMMENTS: TEMPORARY WELL (ABANDONED 2/5/99)	LOCATION: QUARRY-NORTH OF SLOUGH		
DRILLING CONTRACTOR: GEOTECHNOLOGY INC.	DRILL RIG MAKE & MODEL: CME-55 ALL-TERRAIN		
HOLE SIZE & METHOD: 7-1/4" HSA, 4" CME Sampler	ANGLE FROM HORIZONTAL & BEARING: 90	BOTTOM OF HOLE (TD): 14.0	
DRILL FLUIDS & ADDITIVES: None	CASING TYPE, DEPTH, SIZE: N/A	BEDROCK: 14.0	
DATE START: 01/26/99	DATE FINISH: 01/26/99	WATER LEVELS & DATES	

LITHOLOGY BY: Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT
	CME-1	23/29"	rock	LARGE ROCK, 0 -1'.	FILL
			CL	1.0 - 2.5' SILTY CLAY, approx. 20% silt, organics, roots, low to medium plasticity, dark grayish brown (10YR4/2), minor FeOx mottling, firm (pp=1.25), wood chips, slightly moist, CL.	
	CME-2	60/60"	CL/CH	2.5 - 4.0' CLAY, med. to high plasticity, slightly moist, color as above, silty (~15%), only trace of FeOx, roots, firm (pp=1.75), CL/CH.	
			ML	4.0 - 4.5' CLAYEY SILT, color as above, approx. 20% clay, abundant FeOx mottling and blebs, moist, minor very fine sand, very soft (pp<.25), ML.	
5			CL/CH	4.5 - 8.6' SILTY CLAY, med. to high plasticity, approx. 15% silt, dark grayish brown (10YR4/2) with abundant dark reddish brown (5YR3/4) stringers (rootlet replacement) and blebs, slightly moist to moist, firm (pp=1.5), with silty pockets, CL/CH.	NO ALLV.
	CME-3	48/60"			
			ML	8.6 - 10.5' CLAYEY SILT, color and mottling as above, approx. 30% clay also as minor interbeds, rootlets, soft (pp=.5), low to non-plastic, very moist to wet, CaCO3 concretions (2mm) which are coarse sand-sized from 9.5-9.9', ML.	
10			SM	10.5 - 12.5' SILTY SAND, very fine to fine-grained, (~25% silt), minor clay, wet, med. dense, brown (10YR4/3), FeOx, poorly graded, SM.	
	CME-4	18/18"	SC	12.5 - 13.7' CLAYEY SAND WITH GRAVEL, approx. 20% gravel (fine to 2" coarsely crystalline limestone), ~20% clay/silt, wet (almost flowing), loose, SC.	
			CL	13.7 - 14.0' SANDY CLAY, ~30% very fine sand, minor gravel, FeOx stain, very moist, CL.	
15				Auger Refusal and Total Depth @ 14.0 feet. Installed temporary well. Later abandoned and grouted hole to surface with Hole Plug bentonite grout.	
				Note: Soil color is indexed on the Munsell soil color chart.	
				SINGLE WELL HYDRAULIC CONDUCTIVITY (SLUG) TEST RESULTS: K = 1E-4 cm/sec	
20					

TEMPORARY WELL DIAGRAM



Sample Interval | No Sample Taken | minimum | maximum | average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE AND WELL COMPLETION LOG

HOLE NUMBER	QRSB-53
SHEET 1 OF 1	
NORTH (Y):	1028199.77
EAST (X):	747899.30
TOC ELEVATION	460.70
GROUND ELEVATION	458.20
STICKUP	2.50
HYDR CONDUCTIVITY (cm/sec)	K= 5x10^-4 (Slug Test)

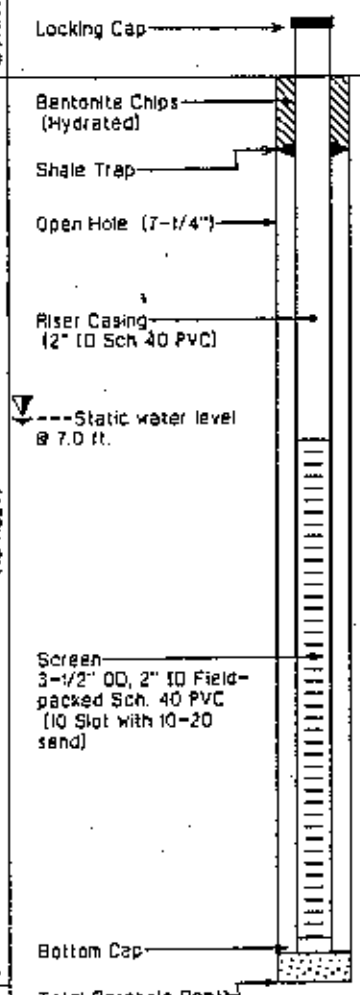
WELL STATUS/COMMENTS	TEMPORARY WELL (ABANDONED 2/5/99)
LOCATION	QUARRY-NORTH OF SLOUGH
DRILLING CONTRACTOR	GEOTECHNOLOGY INC.
DRILL RIG MAKE & MODEL	CME-55 ALL-TERRAIN
HOLE SIZE & METHOD	7-1/4" HSA, 4" CME Sampler
ANGLE FROM HORIZONTAL & BEARING	90
BOTTOM OF HOLE (TD)	18.7
DRILL FLUIDS & ADDITIVES	None
CASING TYPE, DEPTH, SIZE	N/A
BEDROCK	18.7
DATE START	01/20/99
DATE FINISH	01/20/99
WATER LEVELS & DATES	

DEPTH (FT.) FROM GROUND ELEV. TO:

LITHOLOGY BY Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	N# or RQD	GRAPHIC LOG	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT
	CHE-1	33/37"			TS	0 - 7" TOPSOIL, dark brown, loamy, orgainics, roots.	NO ALLV.
					CL/CH	7" - 2.2' SILTY CLAY, med. to high plasticity, very dark grayish brown (10YR3/2), abundant silty pockets with FeOx, roots, organics, slightly moist to moist, CL/CH.	
					CH	2.2 - 3.6' CLAY, high plasticity, dark grayish brown (10YR4/2), minor silt, less mottling and FeOx, hard (pp=2.1), slightly moist, minor coalified wood, CH.	
	CHE-2	60/60"			CL/CH	3.6 - 8.0' SILTY CLAY, mottled dark grayish brown (2.5Y4/2) in clay-rich zones, and reddish brown (5YR4/4) in silty FeOx-rich pockets, approx. 25% silt with FeOx stain, med. to high plasticity, clayey silt bed from 3.6-3.8', firm (pp=1.25), trace of carbonaceous (black) material, moist, CL/CH.	
5							
	CHE-3	50/60"			SC	8.0 - 8.2' CLAYEY SAND, thin lense, color as above, moist fine grained, approx. 30% clay, SC.	
					CH	8.2 - 10.6' SILTY CLAY, as in 3.6-8.0 ft. but less silt (20%), and increased plasticity (high), CH.	
10							
					CH	10.6 - 14.4' CLAY, high plasticity, moist to very moist, firm (pp=1.25), some softer silter zones, dark gray (2.5Y4/1), with minor strong brown (10YR4/6) FeOx mottling, blocky with CaCO3 concretions to 1/4", CH.	
	CHE-4	60/60"					
15					ML	14.4 - 15.4' CLAYEY SILT, approx. 30% clay, very soft (pp<.25), color as above but increased FeOx, medium plasticity, wet, ML.	
					CH	15.4 - 17.2' SILTY CLAY, color as above grading downward to dark gray (N3/), very soft (pp<.25), FeOx blebs (1/2") to 16.6', high plasticity, sticky, CH.	
					CH		
					ML		
	CHE-5	8/8"			SM	17.2 - 17.8' CLAYEY SILT, color as above, ~30% clay, very soft (pp<.25), low plasticity, wet, ML.	
20						17.8 - 18.7' SILTY SAND, color as above, fine to medium-grained sand, poorly graded, med. dense, wet. Limestone gravel to 3" at bottom of hole, SM.	
						Auger Refusal and Total Depth @ 18.7 feet (top of bedrock). Installed a temporary well which was later abandoned, and grouted hole to the surface using Hole Plug bentonite grout.	
						Note: Soil color is indexed on the Muncell soil color chart.	
						SINGLE WELL HYDRAULIC CONDUCTIVITY (SLUG) TEST RESULTS: K = 5E-4 cm/sec	
25							

TEMPORARY WELL DIAGRAM



ELEVATION feet: 455, 450, 445, 440, 435

Sample Interval | No Sample Taken | minimum | maximum | average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE AND WELL COMPLETION LOG

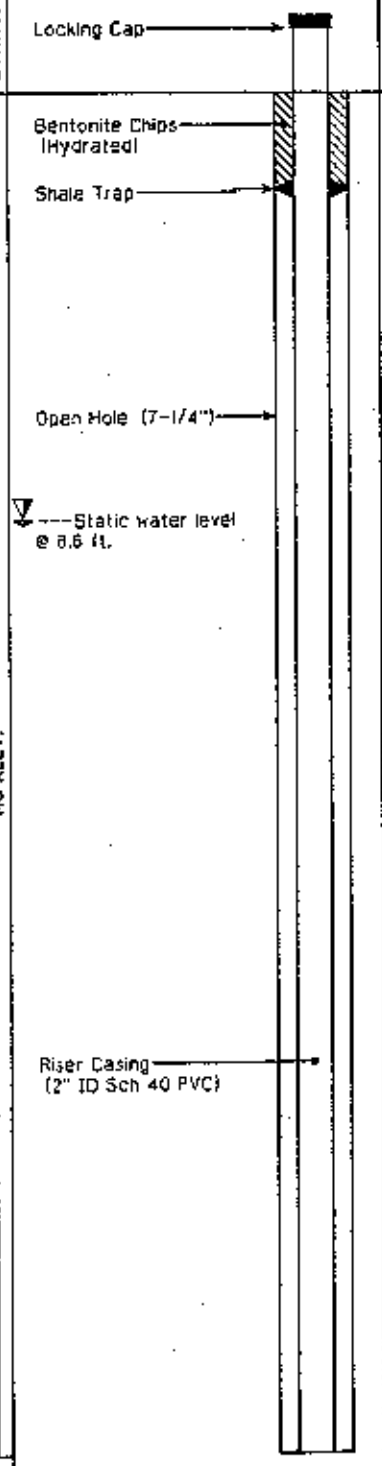
HOLE NUMBER	QRSB-54
SHEET 1 OF 2	
NORTH (Y):	1028117.19
EAST (X):	747907.73
TOC ELEVATION	457.32
GROUND ELEVATION	456.12
STICKUP	1.20
HYDR CONDUCTIVITY (cm/sec)	K= 2×10^{-4} (Slug Test)

WELL STATUS/COMMENTS	TEMPORARY WELL (ABANDONED 2/5/99)
LOCATION	QUARRY-NORTH OF SLOUGH
DRILLING CONTRACTOR	GEOTECHNOLOGY INC.
DRILL RIG MAKE & MODEL	CME-55 ALL-TERRAIN
HOLE SIZE & METHOD	7-1/4" HSA, 4" CME Sampler
ANGLE FROM HORIZONTAL & BEARING	90
BOTTOM OF HOLE (TD)	33.5
DRILL FLUIDS & ADDITIVES	None
CASING TYPE, DEPTH, SIZE	N/A
BEDROCK	Not reached
DATE START	01/26/99
DATE FINISH	01/26/99
WATER LEVELS & DATES	▽ ▼

LITHOLOGY BY Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	N# or RQD	GRAPHIC LOG	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT
	CME-1	26/41"			loss	0 – 1.0' LOSS, likely topsoil.	NO ALLV.
					CL	1.0 – 4.0' SILTY CLAY, low to med. plasticity, very dark grayish brown (10YR3/2), ~35% silt, FeOx mottling, moist, CL.	
	CME-2	60/60"			ML	4.0 – 8.4' CLAYEY SILT, dark grayish brown (10YR4/2), very soft, (pp<.25), low to nonplastic, saturated from approx. 5', abundant FeOx mottling and blebs, minor fine sand, rootlets/organics, with silty clay interbedding (~.1'), ML.	
5							
	CME-3	48/60"			ML	8.4 – 11.7' CLAYEY SILT, as above but color grading to dark gray (10YR4/1) with strong brown (7.5YR4/6) FeOx staining in sand pockets and interbeds, very soft (pp<.25), large (.2') wood chip at 10.7–10.9', ~25% clay, ~15% sand, ML.	
10							
					SM	11.7 – 12.0' SILTY SAND, color as above, fine-grained, poorly graded, approx. 25% silt, some clay, FeOx-stained, SM.	
					CH	12.0 – 13.3' CLAY, high plasticity, dark gray (N4/), with dark reddish brown (5YR3/4) sandy blebs (up to 3mm), very moist, soft (pp=.75), with abundant FeOx-replaced rootlets, CH.	
	CME-4	60/60"			CH	13.3 – 17.3' CLAY, color as above, very soft and moldable, (pulls like taffy), no FeOx, silty, very high plasticity, very moist, concentric sand pockets from 15.6', CH.	
15							
					ML	17.3 – 17.5' SANDY SILT, color as above, nonplastic, wet, ML.	
					CH	17.5 – 18.5' CLAY, as in 13.3–17.3', very moist to wet, some sand interbeds, mod. to high plasticity, CH.	
	CME-5	53/60"			SM	18.5 – 19.5' SILTY SAND, color as above, med. loose, poorly graded, some clay, SM.	
20					CH	19.5 – 22.4' SANDY CLAY, as in 13.3–17.3' with distinct sand pockets to 1.5", high plasticity, moldable, very moist to wet, very soft, increasing sand with depth, with wood pieces (slightly coalified), CH.	

TEMPORARY WELL DIAGRAM



ELEVATION feet

Sample Interval ☐ No Sample Taken ▽minimum ▼maximum ▼average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE AND WELL COMPLETION LOG

HOLE NUMBER: QRSB-54

SHEET 2 OF 2

NORTH(Y): 1028117.19

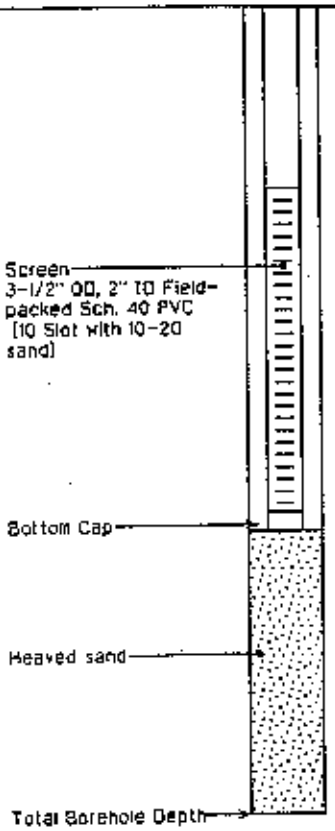
EAST(X): 747907.73

WELL STATUS/COMMENTS: TEMPORARY WELL (ABANDONED 2/5/99)

LOCATION: QUARRY-NORTH OF SLOUGH

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	N# or RQD	GRAPHIC LOG	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT.
					CH		
	CNE-6	60/60"			SC	22.4 - 25.6' CLAYEY SAND, with silt, approx 25% clay, 10% silt, very fine-grained to fine-grained, dark gray (5Y4/1), poorly graded, saturated, loose (flowing) to medium dense, quartzose with subrounded grains, abundant black organics (grain size), micas common, SC.	
26					SC/CL	25.6 - 27.0' CLAYEY SAND/SANDY CLAY, almost equal parts, as above, SC/CL.	
					SP	27.0 - 28.5' SAND, color as above, very fine to fine-grained, approx. 10% silt, med. dense, poorly graded, quartzose (subrounded), less micas and organics (cleaner), SP.	NO ALLY.
	CNE-7	60/60"			SP	28.5 - 33.5' SAND, poorly graded, fine to medium-grained, no fines, abundant dark minerals (likely organics), quartzose, subrounded, SP.	
31							
36						Because of heaving sand, sampler would not advance to the end of the augers. Total Depth @ 33.5' (not at top of bedrock). Installed a temporary well which was later abandoned, and grouted hole to the surface using Hole Plug bentonite grout. Note: Soil color is indexed on the Muncell soil color chart. SINGLE WELL HYDRAULIC CONDUCTIVITY (SLUG) TEST RESULTS: K = 2E-4 cm/sec	
41							

TEMPORARY WELL DIAGRAM



ELEVATION feet: 435, 430, 425, 420, 415

Sample Interval ☐ No Sample Taken minimum maximum average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE AND WELL COMPLETION LOG

HOLE NUMBER	QRSB-55
SHEET 1 OF 2	
NORTH (Y):	1028199.57
EAST (X):	747995.49
TOC ELEVATION	458.04
GROUND ELEVATION	456.34
STICKUP	1.70
HYDR CONDUCTIVITY (cm/sec)	K= 7x10^{-5} (Slug Test)

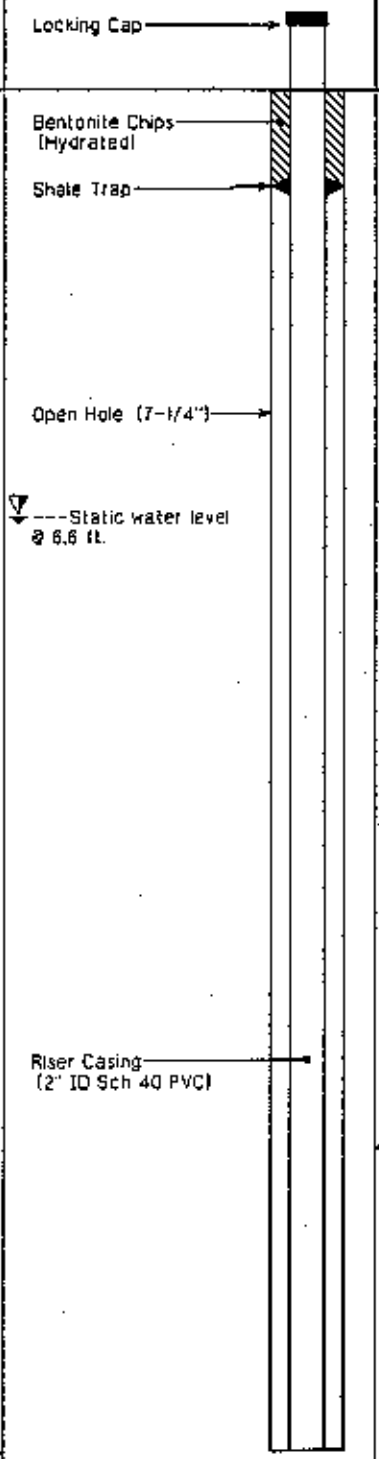
WELL STATUS/COMMENTS	TEMPORARY WELL (ABANDONED 2/5/99)
LOCATION	QUARRY-NORTH OF SLOUGH
DRILLING CONTRACTOR	GEOTECHNOLOGY INC.
DRILL RIG MAKE & MODEL	CME-55 ALL-TERRAIN
HOLE SIZE & METHOD	7-1/4" HSA, 4" CME Sampler
ANGLE FROM HORIZONTAL & BEARING	90
BOTTOM OF HOLE (TD)	27.0
DRILL FLUIDS & ADDITIVES	None
CASING TYPE, DEPTH, SIZE	N/A
BEDROCK	27.0
DATE START	01/21/99
DATE FINISH	01/21/99
WATER LEVELS & DATES	

LITHOLOGY BY Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	N# or RQD	SOIL/ROCK class	DESCRIPTION AND REMARKS
	CME-1	21/35"		TS	0 - 1.0' TOPSOIL, dark brown, silty clay, roots, organics, grass.
				CL/CH	1.0 - 3.0' SILTY CLAY, med. to high plasticity, very silty (~30%) brown (10YR4/3), very soft (pp<.25), moist to very moist, roots, FeOx common, CL/CH.
	CME-2	60/60"		CL/CH	3.0 - 8.0' SILTY CLAY, less silt (decreasing with depth), color as above with strong brown (7.5YR4/6) silty pockets stained with FeOx, very moist, med. plasticity, very soft (pp<.25), crumbly, CL/CH.
5					
	CME-3	60/60"		ML	8.0 - 9.0' CLAYEY SILT, color as above with sand (~15%) interbeds, more abundant FeOx, some MnOx, very soft, ML.
				CL	9.0 - 11.3' SANDY CLAY, with some pure clay interbeds, brown (10YR4/3), low plasticity, wet, sand fraction is fine to medium-grained, silty, at 11.0' color to dark gray (5Y4/1), CL.
10					
				CL	11.3 - 11.8' SILTY SANDY CLAY, color as above, very soft, medium plasticity, carbonaceous wood pieces (coalified), wet, CL.
				SC	11.8 - 12.2' SAND, clayey (~25%), fine-grained, color as above, wood pieces, poorly graded, loose to med. dense, SC.
				CL	12.2 - 13.0' SANDY CLAY, (as in 11.3-11.8') but increased sand and coalified wood, CL.
	CME-4	60/60"		CH	13.0 - 15.0' CLAY, very soft (putty-like), high plasticity, dark gray (5Y4/1), with organic (black) mottling (MnOx?), and rootlets, wet, CL.
15				ML	15.0 - 15.4' CLAYEY SILT WITH SAND, color as above, wet, low plasticity, sand in pockets, very soft, ML.
				CH	15.4 - 19.0' CLAY, as in 13.0-15.0' but with distinctive sand pockets (to 1.5") comprising approx. 10% of sample, very soft, very moist to wet, very high plasticity (modeling clay), sandy bottom .3' CH.
	CME-5	60/60"			
				SM	19.0 - 26.7' SILTY SAND, very dark gray (N3/), very fine to minor fine-grained, approx. 20% silt, 10% clay, poorly graded, saturated, loose, quartose, micas, ~5% dark minerals, SM.
20					

STRAT. UNIT: MO ALLY.

TEMPORARY WELL DIAGRAM



ELEVATION feet

Sample Interval No Sample Taken minimum maximum average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE AND WELL COMPLETION LOG

HOLE NUMBER: QRSB-55

SHEET 2 OF 2

NORTH (Y): 1028199.57

EAST (X): 747995.49

WELL STATUS/COMMENTS: TEMPORARY WELL (ABANDONED 2/5/99)

LOCATION: QUARRY-NORTH OF SLOUGH

DEPTH feet	SAMPLE	SAMPLE/RUN Number	PERCENT Recovery	N# or RQD	GRAPHIC LOG	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT	TEMPORARY WELL DIAGRAM	ELEVATION feet
						SM				435
		CNE-6	48/48"					NO ALLV.	Screen 3-1/2" OD, 2" ID Field-packed Sch. 40 PVC (10 Slot with 10-20 sand)	
26										430
						SP	26.7 - 27.0' SAND, as above but less silt with limestone pieces, SP.		Bottom Cap	
							Auger Refusal and Total Depth @27.0 feet. Installed temporary well which was later abandoned, and grouted hole to the surface using Hole Plug bentonite grout.		Total Borehole Depth 27.0 feet.	
							Note: Soil color is indexed on the Muncell soil color chart.			
							SINGLE WELL HYDRAULIC CONDUCTIVITY (SLUG) TEST RESULTS: K = 7E-5 cm/sec			
31										425
36										420
41										415

Sample Interval No Sample Taken minimum maximum average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

GEOLOG-C

HOLE NUMBER	QRSB-56
SHEET 1 OF 2	
NORTH (Y):	1028291.93
EAST (X):	747988.44
TOC ELEVATION	464.12
GROUND ELEVATION	464.12
STICKUP	
HYDR CONDUCTIVITY (cm/sec)	K= 8.85x10^{-5} (Packer Test)

WELL STATUS/COMMENTS: CHARACTERIZATION BOREHOLE	LOCATION: QUARRY-NORTH OF SLOUGH		
DRILLING CONTRACTOR: GEOTECHNOLOGY, INC.	DRILL RIG MAKE & MODEL: CME-550 ALL TERRAIN		
HOLE SIZE & METHOD: 7-1/4" HSA, 4" CME Sampler	ANGLE FROM HORIZONTAL & BEARING: 90	DEPTH (Ft.) FROM GROUND ELEV. TO: BOTTOM OF HOLE (TD): 35.0	
DRILL FLUIDS & ADDITIVES: WATER	CASING TYPE, DEPTH, SIZE: 3" STEEL (Temporary)	BEDROCK: 16.5	
DATE START: 01-27-99	DATE FINISH: 01-29-99	WATER LEVELS & DATES	

LITHOLOGY BY: Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	N# or RQD	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT	LABORATORY SAMPLES	ELEVATION feet
	CME-1	18/35"		opsoil	TOPSOIL; dark brown, loamy, organics.			
				CL	6" – 5.9' FILL, (Gravelly Clay), approx. 35% limestone gravel (fine to cobble-size), in silty clay matrix, medium plasticity, moist, firm, roots, organics, brown (10YR4/3), CL.	FILL		
	CME-2	34/60"						460
5								
				SM	5.9 – 6.4' SILTY SAND (fill?), very fine to minor fine- grained, approx. 30% silt, minor clay, medium dense, moist to very moist, color as above, poorly graded, some roots, no mottling, SM.			
				CL	6.4 – 8.8' SANDY CLAY (fill?), color as above, approx. 35% very fine sand and silt, very soft, very moist to wet at ~8 ft., pure clay clasts, sand pockets, organic (black) clasts, minor FeOx, large (2.5") limestone gravel clast @ 8.5' (stuff?), CL.			
	CME-3	54/60"						455
				CL	8.8 – 10.5' SILTY CLAY, dark grayish brown (10YR4/2) with reddish brown (5YR4/4) FeOx mottling in the form of root replacement and blebs, medium to high plasticity, moist to very moist, firm (pp=1.0), decreasing plasticity and increase in sand with depth CL.			
10				SC	10.5 – 13.0' CLAYEY SAND, brown (10YR4/3), no mottling, approx. 35% fines, medium dense, fine-grained, poorly graded, quartzose, SC.	MO ALLV.	QRSB-56-10.5-13 (G)	
							---Approx. water level through augers at 12.7'	
	CME-4	56/42"		CL	13.0 – 15.5' SANDY CLAY, dark grayish brown (10YR4/2) with strong brown brown (7.5YR4/6) FeOx blebs and root replacement, dark organics, abundant clay (~50%) mixed with silt and as interbeds, very soft (pp<.25), very moist, low plasticity, CL.			450
15							QRSB-56-13-15.5 (G,A)	
				CL	15.5 – 16.5' SANDY CLAY, color as above, approx. 25–30% fine sand, wet, chert gravel to 2" in bottom of sampler, CL. Auger refusal at 16.5 (top of rock), switch to NQ coring.			
	RUN-1	41/42"	0	lms. sht	16.5 – 23.8' INTERBEDDED LIMESTONE AND CALCAREOUS SHALE, approx. ~80% limestone. Limestone is light olive gray (5Y6/1) to 22.4' then med. light gray (N6), very finely crystalline, to lithographic, argillaceous, hard, slightly weathered, fossiliferous, very thin-bedded, mod. porosity to 22.4' then weak, very close fracturing with FeOx and clay common on fracts., coarser and very fossiliferous from 22.4–23.8'. *Shale* is olive gray (5Y4/1), and often altered (stained) to mod. yellowish brown (10YR5/4), or less commonly dark yellowish orange (10YR6/6), mod. weathered, mod. hard to soft, very thin to extreme bedding, with abund. fossils, small (10mm) carbonaceous shale bed at 22.0'. (DECORAH GROUP)	Odg	G=Gradation A=Atterberg Limits	445
20	RUN-2	54/60"	16				~ 16.4'	

Sample Interval No Sample Taken minimum maximum average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

HOLE NUMBER: QRSB-56

SHEET 2 OF 2

NORTH (Y): 1028291.93

EAST (X): 747988.44

WELL STATUS/COMMENTS: CHARACTERIZATION BOREHOLE

LOCATION: QUARRY-NORTH OF SLOUGH

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery (0 – 100)	N# or RQD	GRAPHIC LOG	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT	LABORATORY SAMPLES	ELEVATION feet
					lms shl				
					shl	23.8 – 25.1' SHALE, dark greenish gray (5G4/1), soft, fissile, with minor limestone interbeds to 20mm, fossiliferous banding, slightly weathered, some non-indurated zones (clay-like), occas. FeOx staining.			440
	RUN-3	56/60"	84			25.1 – 25.9' SHALE, olive black (5Y2/1), carbonaceous (oil shale), with small stringers of CaCO3, hard, fresh.			
26					cly	25.9 – 26.3' BENTONITIC CLAY bed, minor fissility, slightly indurated, medium light gray (N6), high porosity.			
					shl				
					lms shl				
					lms	26.3 – 26.5' SHALE, greenish gray as in 23.8 – 25.1'.	Ddg		
						26.5 – 27.6' INTERBEDDED LIMESTONE AND CALCAREOUS SHALE, as before but decreased shale and increase in intergranular silt and clay that is FeOx-stained to light olive brown (5Y5/6), high porosity. DECORAH GROUP			435
	RUN-4	56/60"	57			27.6 – 35.0' LIMESTONE, pale yellowish brown (10YR8/2), with stringer-like dark (olive black) shale parting to 10mm, some which are FeOx-stained to light olive brown (5Y5/6), thin-bedded, lithographic, slightly weathered to fresh, hard, with very hard tan-colored dolomite nodules to 3" from 32.3 – 33.5' above and below a soft shale bed from 32.8–33.3' which is fissile, olive gray (5Y4/1) except for the bottom .4' which is light gray (N7) and bentonitic. Limestone shows a 1" vug at 30.7' partially filled with quartz crystals. It also exhibits possible stylolites and overall is closely (2.5–8") fractured, weak porosity.			
31									
					shl				
					cly				
	RUN-5	20/20"	41		lms		Opl		430
						[Decorah Group to 32.9' then Plattin Limestone]			
						Total Depth 35.0'. Backfilled borehole with Hole Plug Bentonite Grout.			
36						Note: Soil color is indexed on the Munsell soil color chart. Rock color is from the GSA rock color chart.			
						CONSTANT HEAD SINGLE PACKER TEST RESULTS: 19.0 – 26.0 ft. K= 1.1E-4 cm/sec 25.0 – 35.0 ft. K= No water take.			425
41									420

Sample Interval ☐ No Sample Taken ▽minimum ▼maximum ▼average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

GEOLOG-C

HOLE NUMBER	GRSB-57
SHEET 1 OF 2	
NORTH (Y):	1028354.03
EAST (X):	748131.34
TOC ELEVATION	456.58
GROUND ELEVATION	456.58
STICKUP	
HYDR CONDUCTIVITY (cm/sec)	K= 7.8x10^{-5} (Packer Test)

WELL STATUS/COMMENTS	CHARACTERIZATION BOREHOLE
LOCATION	QUARRY-NORTH OF SLOUGH
DRILLING CONTRACTOR	GEOTECHNOLOGY, INC.
DRILL RIG MAKE & MODEL	CME-550 ALL TERRAIN
HOLE SIZE & METHOD	7-1/4" HSA, 4" CME Sampler
ANGLE FROM HORIZONTAL & BEARING	90
DRILL FLUIDS & ADDITIVES	WATER
CASING TYPE, DEPTH, SIZE	n/a
DATE START	02-02-99
DATE FINISH	02-03-99
DEPTH (FT.) FROM GROUND SURF. TO: BOTTOM OF HOLE (TD)	29.8
BEDROCK	8.5
WATER LEVELS & DATES	

LITHOLOGY BY Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	N# or RQD	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT	LABORATORY SAMPLES	ELEVATION feet
	CME-1	25/38"		opsoil	0 -6" TOPSOIL, dark brown, loamy, organics.			
				CL	6" - 3.0' GRAVELLY CLAY, (Fill), approx. 20% limestone gravel to 2", dark grayish brown (10YR4/2), low plasticity, silt and sand pockets (~20%), abundant wood pieces and FeOx stain CL			455
	CME-2	46/60"		CL	3.0 - 4.9' SILTY CLAY, low to med. plasticity, very dark grayish brown (10YR3/2), moist, firm (pp=1.5), no gravel or sand, some (<5%) carbonaceous material (coalified wood), increasing silt and FeOx with depth, CL.	NO ALLV.		
5				CL	4.9 - 6.3' SANDY, SILTY CLAY, interbedded in approximately equal fractions, clay and silt with lenses of fine sand (~15%) overall low plasticity, very dark grayish brown (10YR3/2) with abundant strong brown (7.5YR4/6), FeOx mottling and blebs (to 20%), moist to 6.0' then very moist to wet, very soft (pp=<.25), some black carbonaceous organics, rootlets (with FeOx replacement) sandier with depth, CL.		---Approx. water level through augers at 5.7' GRSB-57-5-8.5 (G,A)	450
	CME-3 RUN-1	14/18"	0	SC lms shl	6.3 - 8.5' CLAYEY SAND with GRAVEL, as above, but increased fine sand and gravel (to 3"), composed of limestone and chert SC. Auger Refusal at 8.5 ft (top of rock), switch to NQ wireline coring.			
10	RUN-2	50/60"	0		8.5 - 16.9' INTERBEDDED LIMESTONE & CALCAREOUS SHALE, approx. 20% shale, limestone is light olive gray (5Y6/1) to 15.0' then more medium gray (N5), abundant FeOx stain to 9.8' then occasional, very finely crystalline to sublithographic; argillaceous, hard, slightly weathered, close fracturing with clay and FeOx common, fossiliferous. *Shale* is olive gray (5Y4/1), in beds to .1', altered and stained to 9.8' then occasionally, slightly to occasional moderately weathered, hard, very thin to extreme bedding (slightly irregular), with abundant fossils. [DECORAH GROUP]		G=Gradation A=Atterberg Limits	445
15	RUN-3	26/36"	60			Odg	~ 18.3'	440
	RUN-4	24/24"	70	shl	16.9 - 18.4' SHALE, dark greenish gray (5G4/1), with some FeOx staining, fissile, soft, slightly to moderately weathered, some clay-like zones, minor (.1') very fossiliferous (fossil hash) limestone beds.			
				lms shl	18.4' - 19.9' INTERBEDDED LIMESTONE & CALCAREOUS SHALE, as before, less shale content, minor FeOx.			
20	RUN-5	60/60"	84					
				cly shl lms	19.9 - 20.0' BENTONITIC CLAY, medium light gray (N6), soft, slight fissility. 20.0 - 20.5' SHALE, greenish gray as before, banded with fossiliferous limestone.			

Sample Interval ☐ No Sample Taken ▽minimum ▼maximum ▼average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

HOLE NUMBER: QRSB-57

SHEET 2 OF 2

NORTH (Y): 1028354.03

EAST (X): 748131.34

WELL STATUS/COMMENTS: CHARACTERIZATION BOREHOLE

LOCATION: QUARRY-NORTH OF SLOUGH

DEPTH feet	SAMPLE	SAMPLE/RUN Number	PERCENT Recovery	N# or RQD	GRAPHIC LOG	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT	LABORATORY SAMPLES	ELEVATION feet
			0 100			lms	20.5 - 29.8' LIMESTONE, with stringer-like shale partings (hairline to 10mm), pale yellowish brown (10YR6/2), very slightly weathered, hard, with tan, hard dolomite nodules from 25-27' above and below a shale bed at 26.3-26.8'. The shale is comprised of a bentonitic shale (clay-like) from 26.3-26.5', and a carbonaceous shale which is olive gray (5Y4/1) from 26.5-26.8'. Overall, the limestone shows low porosity, possibly stylolitic, fossiliferous, closely fractured (usually along shale partings). (DECORAH GROUP to 26.8' then PLATTIN LIMESTONE)	Odg		435
		RUN-8	60/60"	88						
26										430
						cly shl lms		Opl		
31							Total Depth 29.8'. Grouted hole to surface with Hole Plug Bentonite Grout.			425
							Note: Soil color is indexed on the Muncell soil color chart. Rock color is from the GSA rock color chart.			
							CONSTANT HEAD SINGLE PACKER TEST RESULTS: 10.0 - 17.8 ft. K = 7.8E-5 18.0 - 29.8 ft. K = No water take			
36										420
41										415

Sample Interval No Sample Taken minimum maximum average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE AND WELL COMPLETION LOG

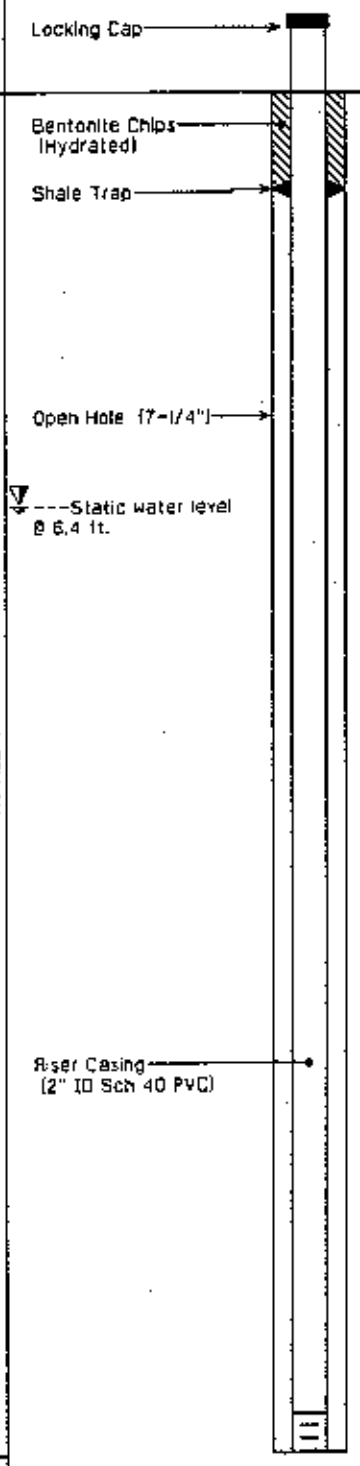
HOLE NUMBER	QRSB-58
SHEET 1 OF 2	
NORTH (Y):	1028297.53
EAST (X):	748197.89
TOC ELEVATION	457.16
GROUND ELEVATION	455.26
STICKUP	1.90
HYDR CONDUCTIVITY (cm/sec)	K= 9x10^-4 (Slug Test)

WELL STATUS/COMMENTS: TEMPORARY WELL (ABANDONED 2/5/99)	LOCATION: QUARRY-NORTH OF SLOUGH		
DRILLING CONTRACTOR: GEOTECHNOLOGY INC.	DRILL RIG MAKE & MODEL: CME-55 ALL-TERRAIN		
HOLE SIZE & METHOD: 7-1/4" HSA, 4" CME Sampler	ANGLE FROM HORIZONTAL & BEARING: 90	BOTTOM OF HOLE (TD): 28.3	
DRILL FLUIDS & ADDITIVES: None	CASING TYPE, DEPTH, SIZE: N/A	BEDROCK: 28.3	
DATE START: 01/25/99	DATE FINISH: 01/25/99	WATER LEVELS & DATES	

LITHOLOGY BY: Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT
	CME-1	32/42"	TS	0 - 1.2' TOPSOIL, very dark brown, organics, roots, grass, loamy.	
			CL/CH	1.2 - 1.8 SILTY CLAY, med. plasticity, very dark grayish brown (10YR3/2), firm (pp=1.25), moist, organics, ~15% silt, CL/CH.	
			ML	1.8 - 2.7' SILT, brown (10YR4/3) with strong brown (7.5YR4/6) FeOx staining, ~25% clay, very soft (pp<.25), very moist, low plasticity, some .1' clay interbeds, ML.	
	CME-2	60/60"	CL	2.7 - 4.4' SILTY CLAY, low plasticity, very silty (~30%) minor very fine sand, dark grayish brown (10YR4/2), with FeOx (strong brown) mottling, CL.	
5			ML CL	4.4 - 6.0' CLAYEY SILT/SILTY CLAY, brown (10YR4/3), low plasticity, very soft (pp<.25), moist, FeOx blebs, sandy zones, ML/CL.	
			CL	6.0 - 8.3' SILTY CLAY, color as above, soft (pp=.25), moist, low plasticity, sand lenses to .1', abundant FeOx blebs and rootlet replacement, organics, ~30% silt, possible MnOx (no dendrites), less silt with depth, CL.	
	CME-3	60/60"	OL CL	8.3 - 9.5' LIGNITIC CLAY, very dark gray (10YR3/1), with coalified wood chips fine to ~1.5" (approx. 30% of total section), very moist to wet, med. plasticity, soft (pp=.50), OL/CL.	
10			CL	9.5 - 12.2' SILTY CLAY, very dark gray (2.5Y3/1), stratified to laminated with silt (30%), and light colored fine sand beds (15%), some angled bedding (slump?), very moist, soft (pp=.75), med. plasticity, abundant organics as coalified wood, CL.	HO ALLV.
			ML	12.2 - 12.7' CLAYEY SILT, color as above, non-plastic, some sand stringers, soft (pp=.5), very moist, ML.	
			CL		
	CME-4	60/60"	OL CL	12.7 - 13.2' SILTY CLAY, as in 9.5-12.2' but with increased organics, CL.	
15			CL	13.2 - 14.3' LIGNITIC CLAY, approx. 40% organics in laminations (lignite), very dark gray (2.5Y3/1) to black (2.5Y2.5/1), low plasticity, soft (pp=.25), very moist, OL/CL.	
			CH	14.3 - 15.7' SILTY CLAY, interbedded with lignitic clay/lignite and silt, laminated, angled (25 degrees) bedding, CL.	
				15.7 - 18.2' CLAY, dark gray (N4/), very high plasticity, very soft (pp<.25), moldable, very moist, blocky texture with conchoidal breakage fractures, CH.	
	CME-5	60/60"	SP	18.2 - 22.9' SAND, fine to medium-grained, poorly graded, wet, loose to med. dense, clean (little fines), quartzose (subrounded to rounded), trace micas and dark minerals, dark grayish brown (2.5Y4/2), fine to very fine-grained and silty from 18.8-19.0' SP.	
20					

TEMPORARY WELL DIAGRAM



ELEVATION feet: 455, 450, 445, 440, 435

Sample Interval ☐ No Sample Taken ▽minimum ▼maximum ▼average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE AND WELL COMPLETION LOG

HOLE NUMBER: QRSB-58

SHEET 2 OF 2

NORTH(Y): 1028297.53

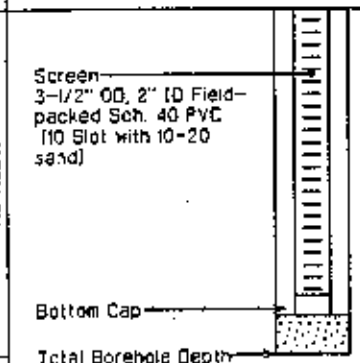
EAST (X): 748197.89

WELL STATUS/COMMENTS: TEMPORARY WELL (ABANDONED 2/5/99)

LOCATION: QUARRY-NORTH OF SLOUGH

DEPTH feet	SAMPLE	SAMPLE/RUN Number	PERCENT Recovery	N# or RQD	GRAPHIC LOG	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT
						SP		NO ALLV.
						CH	22.8 - 23.8' CLAY, as in (5.7-18.1', sandy last .2' (clayey sand), CH.	
		CME-6	32/32"			SP	23.6 - 26.3' SAND, fine to very fine-grained, poorly graded, med. dense, wet, some silt (~10%), abundant dark minerals/organic specks, quartzose, subrounded to angular (some matics), with limestone gravel to 3" in bottome .3', SP.	
26							Auger Refusal and Total Depth @26.3 feet. Installed temporary well which was later abandoned, and grouted hole to the surface using Hole Plug bentonite grout.	
							Note: Soil color is indexed on the Muncell soil color chart.	
							SINGLE WELL HYDRAULIC CONDUCTIVITY (SLUG) TEST RESULTS: K = 9E-4 cm/sec	
31								
36								
41								

TEMPORARY WELL DIAGRAM



ELEVATION feet: 430, 425, 420, 415

Sample Interval | No Sample Taken | minimum | maximum | average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE AND WELL COMPLETION LOG

HOLE NUMBER	QRSB-59
SHEET 1 OF 1	
NORTH (Y):	1028398.55
EAST (X):	748398.03
TOC ELEVATION	456.78
GROUND ELEVATION	454.78
STICKUP	2.00
HYDR CONDUCTIVITY (cm/sec)	K= 3x10^{-4} (Slug Test)

WELL STATUS/COMMENTS: TEMPORARY WELL (ABANDONED 2/5/99)	LOCATION: QUARRY-NORTH OF SLOUGH		
DRILLING CONTRACTOR: GEOTECHNOLOGY INC.	DRILL RIG MAKE & MODEL: CME-55 ALL-TERRAIN		
HOLE SIZE & METHOD: 7-1/4" HSA, 4" CME Sampler	ANGLE FROM HORIZONTAL & BEARING: 90	BOTTOM OF HOLE (TD): 22.5	
DRILL FLUIDS & ADDITIVES: None	CASING TYPE, DEPTH, SIZE: N/A	BEDROCK: 22.5	
DATE START: 01/20/99	DATE FINISH: 01/20/99	WATER LEVELS & DATES	

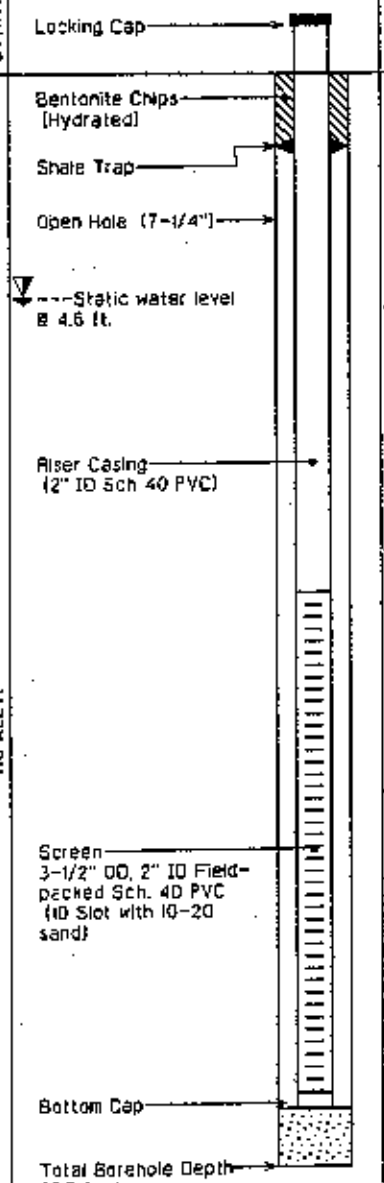
DEPTH: FT.) FROM GROUND ELEV. TOC

LITHOLOGY BY: Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	N# or RQD	SOIL/ROCK Class	DESCRIPTION AND REMARKS
	CME-1	27/30"		Loss	0 - 1.0' Loss
				CL	1.0 - 1.5' SILTY CLAY, med. to high plasticity, dark grayish brown (10YR4/2), soft (pp=.25), organics, grass, CL.
				CL	1.5 - 4.3' SILTY CLAY, with gravel (fill?), moist, med. plasticity, brown (10YR4/3, very silty (30%) in pockets, ~10% limestone gravel to 2", organics, roots, soft to very soft (pp=.5 to <.25), softer and siltier with depth, CL.
	CME-2	50/60"			
5				ML	4.3 - 8.0' CLAYEY SILT, color as above with abundant reddish brown (5YR4/4) FeOx mottling, very soft (pp<.25), approx. 35% clay as interbeds to .2', occas. organics (black), minor very fine sand, wet from ~5.3', ML.
	CME-3	30/60"			
10				ML	8.0 - 10.3' SANDY SILT, less clay (~20%) and more very fine sand (~20%), color to dark gray (2.5Y4/1), wet, very soft, organics, no FeOx (reducing conditions), ML.
				CL	10.3 - 13.5' SILTY CLAY, interbedded with silt (~30%) and sand (20%), very dark gray (N3/1, saturated, some medium-grained, poorly graded sand, very soft (clay), abundant black organics, abundant coalified wood (to 2") from 11.5', trace gravel to 1.5", CL.
	CME-4	40/60"			
15				SM	13.5 - 16.6' SILTY SAND, very fine to coarse-grained, dark gray (N4/1), approx. 15% silt, 10% clay and as occasional partings to .3', loose to med. dense, quartzose, subrounded to rounded, ~5% dark minerals, some organics, coarsening downward to coarse- grained, SM.
				SW	16.6 - 20.3' SAND, as above but little fines and coarser, medium to coarse-grained, SW.
	CME-5	48/50"			
20				CL	20.3 - 21.2' SANDY CLAY, very dark gray (N3/1), very soft (pp<.25), approx. 20% very fine sand, some silt, wet, medium plasticity, CL.
				CH	21.2 - 22.3' CLAY, high plasticity, very soft, color as above, wet, CH.
				SP	22.3 - 22.5' GRAVELLY SAND, color as above, very fine to fine- grained, poorly graded with ~30% coarsly crystalline limestone gravel to 2.5", med. dense to dense, wet, SP.
25					Auger Refusal and Total Depth @22.5 feet. Installed temporary well which was later abandoned, and grouted hole to the surface using Hole Plug bentonite grout.
					Note: Soil color is indexed on the Munsell soil color chart.
					SINGLE WELL HYDRAULIC CONDUCTIVITY (SLUG) TEST RESULTS: K = 3E-4 cm/sec

STRAT. UNIT: NO ALLY.

TEMPORARY WELL DIAGRAM



ELEVATION feet

Sample Interval ☐ No Sample Taken ▼minimum ▼maximum ▼average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

HOLE NUMBER	QRSB-60
SHEET 1 OF 2	
NORTH (Y):	1028479.87
EAST (X):	748409.94
TOC ELEVATION	455.41
GROUND ELEVATION	455.41
STICKUP	
HYDR CONDUCTIVITY (cm/sec)	K= .0000x10^-1 (Packer Test)

WELL STATUS/COMMENTS	CHARACTERIZATION BOREHOLE
LOCATION	QUARRY-NORTH OF SLOUGH
DRILLING CONTRACTOR	GEOTECHNOLOGY, INC.
DRILL RIG MAKE & MODEL	CME-550 ALL TERRAIN
HOLE SIZE & METHOD	7-1/4" HSA, 3" CME Sampler
ANGLE FROM HORIZONTAL & BEARING	90
BOTTOM OF HOLE (TD) (DEPTH (FT.) FROM GROUND ELEV. 1C)	30.4
DRILL FLUIDS & ADDITIVES	WATER
CASING TYPE, DEPTH, SIZE	
BEDROCK	10.7
STICKUP	
DATE START	02-04-99
DATE FINISH	02-04-99
WATER LEVELS & DATES	

LITHOLOGY BY: Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	N# or RQD	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT	LABORATORY SAMPLES	ELEVATION feet
	CNE-1	39/46"		opsoil	0 - 8" TOPSOIL, dark brown, grass, gravel, organics.	NO ALLV.		455
				CL	.5 - 3.2' GRAVELLY CLAY. (Fill?), very dark grayish brown (10YR4/2), approx. 15% angular chert gravel to 1", grass, organics, roots, slightly moist, firm (pp=2.0), low plasticity, silt and minor sand, FeOx, CL.			
	CNE-2	50/60"			3.2 - 5.7' GRAVELLY SILTY CLAY, (fill?), dark gray (5Y4/1), silty (~20%), and approx. 10% subangular to subrounded gravel, rootlets, grass, jumbled texture, slightly moist, hard, (pp=2.75), low plasticity, CL.		---Approx. water level through augers at 3.5'	
5							QRSB-60-3.2-5.7 (G,A)	450
				CL/ML	5.7 - 8.4' SILTY CLAY/CLAYEY, SANDY SILT, interbedded ~50/50, firm (pp=1.75 in clayey zones) and very soft (silty zones pp<.25), moist to (very moist starting @ 7ft.), dark grayish brown (10YR4/2), with abundant strong brown FeOx mottling that increases with depth, low plasticity, abundant rootlets and black carbonaceous material, minor fine sand, CL/ML.			
	CNE-3	18/22"		CH	8.4 - 10.5' CLAY, very dark grayish brown (10YR3/2), medium to high plasticity, firm (pp=1.25), moist, abundant FeOx nodules, occasional silty lenses, CH.		QRSB-60-8.4-10.4 (G,A)	
10								445
	RUN-1	41/41"	9	GC / lms. shl	10.5 - 10.7' LINESTONE GRAVEL, to 3", minor (20%) clay as above, GC. Auger refusal at 10.7' (top of rock), switch to NQ coring.		G=Gradation A=Atterberg Limits	
	RUN-2	18/18"	92		10.7 - 18.2' INTERBEDDED LIMESTONE AND CALCAREOUS SHALE, approx. ~80% limestone. Limestone is light olive gray (5Y6/1) to 16.8' then med. light gray (N6), lithographic, very thin-bedded, (irregular), slightly weathered, argillaceous, very fossilliferous, very closely to closely fractured, hard, with FeOx stain on fracts., overall moderate porosity to 16.8' then weak. *Shale* is olive gray (5Y4/1), but is commonly altered (stained) to mod. yellowish brown (10YR5/4) from 10.7-13.6', moderate to high porosity, very thin to extreme bedding (wavy), occasional softer clayey beds, fissile, very fossilliferous (particulary on tops and bottoms of shale bed (brachiopods), minor brownish black organic shale beds @ 14.6', very fossilliferous with coarser texture from 16.8-18.2'. [DECORAH GROUP]	Ddp		
15	RUN-3	59/60"	72				2 17.5'	440
				shl	18.2 - 18.8' SHALE, dark greenish gray (5G4/1), soft, fissile, with minor interbeds (10mm) of limestone, fossilliferous (as hash), slightly weathered, with some clay beds (less indurated shale).			
20	RUN-4	60/60"	78	lms. shl	19.8 - 20.8' INTERBEDDED LIMESTONE AND CALCAREOUS SHALE, as before, very fossilliferous.			435
				shl / cly	20.8 - 20.9' SHALE, olive black (5Y2/1), organic (oil-shale looking), with conspicuous light gray limestone "striping", hard, slightly weathered.			

Sample Interval ☐ No Sample Taken ▽minimum ▼maximum ▼average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

HOLE NUMBER: QRSB-60

SHEET 2 OF 2

NORTH (Y): 1028479.87

EAST (X): 748409.94

WELL STATUS/COMMENTS: CHARACTERIZATION BOREHOLE

LOCATION: QUARRY-NORTH OF SLOUGH

DEPTH feet	SAMPLE	SAMPLE/RUN Number	PERCENT Recovery	N# or RQD	GRAPHIC LOG	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT	LABORATORY SAMPLES	ELEVATION feet
						cly, shl, lms, shl, lms	20.8 – 21.2' BENTONITIC CLAY bed, minor fissility but mostly soft, sticky, medium light gray (N8), high porosity, orange FeOx stain at top. 21.2 – 21.5' SHALE, dark greenish gray (as before) with abundant FeOx along bedding, very fissile. 21.5 – 22.7' INTERBEDDED LIMESTONE AND CALCAREOUS SHALE, as before but less shale which is softer, abundant FeOx staining (light olive brown 5Y5/6), with high porosity.	Odg		
26		RUN-5	24/26"	81			22.7 – 30.4' LIMESTONE, pale yellowish brown (10YR6/2), with whispy stringer-like shale partings to 8mm, which are brownish black (5YR2/1), lithographic, thin-bedded, hard, slightly weathered to fresh, FeOx staining on partings/fractures to 27.6', shaty partings may be stylolitic, dolomite infilled irregular vug at 26.8', very large (2") conspicuous tan dolomite nodules at 27.5' and 28.2' above and below a clayey shale (olive gray) from 27.6–27.8' which is underlain by a clay bed (bentonitic, med. gray), from 27.9–28.2'. Overall, close to medium fracturing, weak porosity. (Decorah Group to 28.2' then Plattin Limestone)			430
		RUN-6	34/34"	89		shl, cly, lms		Opl		425
31							Total Depth 30.4'. Grouted borehole to the surface using Hole Plug Bentonite Grout. Note: Soil color is indexed on the Muncell soil color chart. Rock color is from the GSA rock color chart. CONSTANT HEAD SINGLE PACKER TEST RESULTS: 12.5 – 20.4 ft. K= No water take			420
36										415
41										

Sample Interval ☐ No Sample Taken ▼minimum ▼maximum ▼average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE AND WELL COMPLETION LOG

HOLE NUMBER	QRSB-61
SHEET 1 OF 1	
NORTH (Y):	1028579.99
EAST (X):	748597.51
TOC ELEVATION	461.09
GROUND ELEVATION	459.09
STICKUP	2.00
HYDR CONDUCTIVITY (cm/sec)	K= 6x10^{-5} (Slug Test)

WELL STATUS/COMMENTS	TEMPORARY WELL (ABANDONED 2/6/99)
LOCATION	QUARRY-NORTH OF SLOUGH
DRILLING CONTRACTOR	GEOTECHNOLOGY INC.
DRILL RIG MAKE & MODEL	CME-55 ALL-TERRAIN
HOLE SIZE & METHOD	7-1/4" HSA, 4" CME Sampler
ANGLE FROM HORIZONTAL & BEARING	90
DRILL FLUIDS & ADDITIVES	None
CASING TYPE, DEPTH, SIZE	N/A
DATE START	01/19/99
DATE FINISH	01/20/99
DEPTH (FT.) FROM GROUND ELEV. TO: BOTTOM OF HOLE (TD)	13.5
BEDROCK	13.5
WATER LEVELS & DATES	

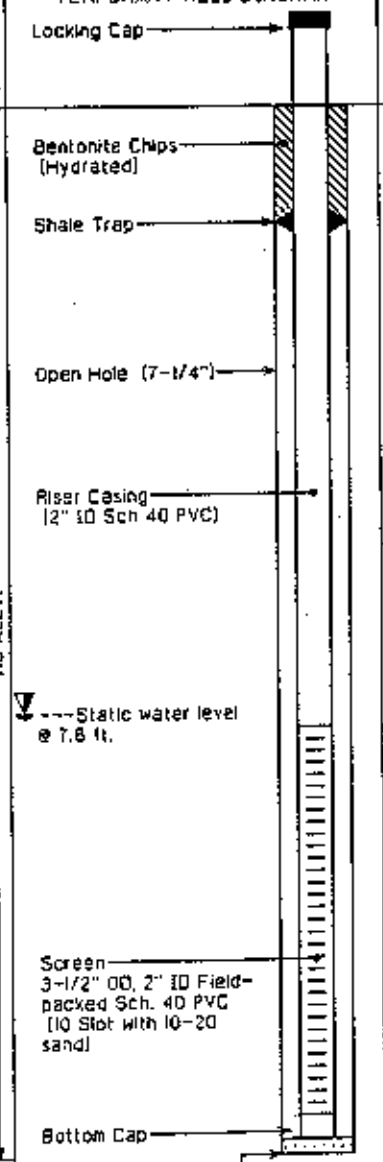
LITHOLOGY BY: Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	N# or RQD	GRAPHIC LOG	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT
	CHE-1	25/37"			TS	0 - 1.0' TOPSOIL, very dark brown, loamy roots, organic.	NO ALLY.
					CL/CH	1.0 - 1.8' CLAY, some silt, very dark gray (10YR3/1), med. to high plasticity, moist, organics, firm (pp=1.75), CL/CH.	
					CL/ML	1.8 - 2.5' SILTY CLAY/CLAYEY SILT, very dark grayish brown (10YR3/2), some fine sand (~10%), moist, low plasticity, some roots, very soft (pp<.25), CL/ML.	
	CHE-2	60/60"			CH	2.5 - 4.8' CLAY, high plasticity, very dark grayish brown (10YR4/2), firm (pp=1.5), occas. silty lenses (.1'), rootlets, minor FeOx blebs, CH.	
5					ML	4.8 - 5.1' SILT, light olive brown (2.5Y5/3), slightly moist, FeOx blebs, non-plastic, trace clay, very soft (pp<.25), ML.	
					CH	5.1 - 6.7' CLAY, dark grayish brown (10YR4/2), very blocky and fractured with abundant FeOx on fracts and as blebs, med. to high plasticity, slightly moist, hard (pp=2.5), waxy, .1' silt lense at 5.9', CH.	
						6.7 - 8.8' CLAY, color as above, not blocky, high plasticity, firm (pp=1.75), moist, siltier, FeOx common, CH.	
	CHE-3	60/60"				8.8 - 10.7' CLAY, as above but with distinctive FeOx mottling, CaCO3 concretions common, CH.	
10					ML	10.7 - 11.1' CLAYEY SILT with sand, color as above, very moist, non-plastic, very soft (pp<.25), ML.	
					CH	11.1 - 12.7' CLAY as in 8.8-10.7' but more laminated, soft (pp=.75), some black stringers (rootlets), CH.	
					ML	12.7 - 13.2' SANDY SILT, color as above, very moist to wet, ~25% fine sand and FeOx (less than above), ~10% clay, very soft (pp<.25), ML.	
	CHE-4	4/4"			GM	13.2 - 13.5' GRAVEL, limestone gravel to 3" in sandy silt (as above), GM.	
15						Auger Refusal and Total Depth @ 13.5 feet. Installed temporary well. Later abandoned and grouted to the surface with Hole Plug bentonite grout.	

Note: Soil color is indexed on the Huncell soil color chart.

SINGLE WELL HYDRAULIC CONDUCTIVITY (SLUG) TEST RESULTS: K = 6E-5 cm/sec

TEMPORARY WELL DIAGRAM



ELEVATION feet

Sample Interval | No Sample Taken | minimum | maximum | average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE AND WELL COMPLETION LOG

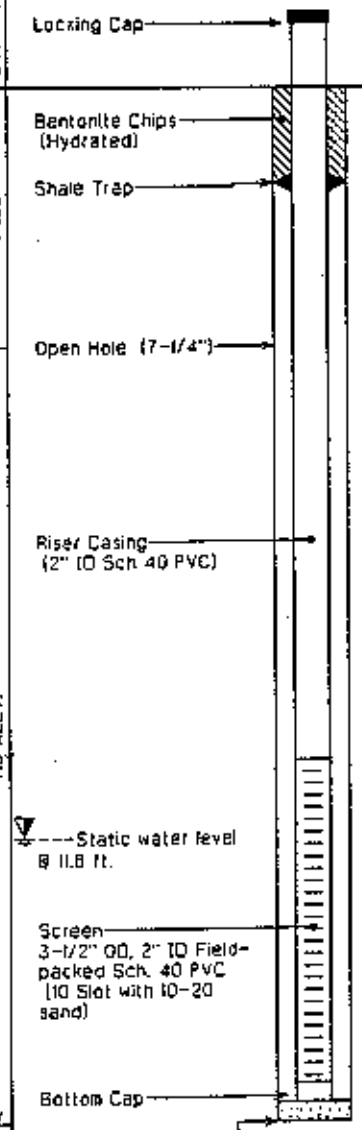
HOLE NUMBER	QRSB-62
SHEET 1 OF 1	
NORTH (Y):	1028702.38
EAST (X):	748900.97
TOC ELEVATION	464.46
GROUND ELEVATION	462.96
STICKUP	1.50
HYDR CONDUCTIVITY (cm/sec)	K= 3x10^{-4} (Slug Test)

WELL STATUS/COMMENTS	TEMPORARY WELL (ABANDONED 2/3/99)
LOCATION	QUARRY-NORTH OF SLOUGH
DRILLING CONTRACTOR	GEOTECHNOLOGY INC.
DRILL RIG MAKE & MODEL	CME-55 ALL-TERRAIN
HOLE SIZE & METHOD	7-1/4" HSA, 4" CME Sampler
ANGLE FROM HORIZONTAL & BEARING	90
BOTTOM OF HOLE (TD)	16.0
DRILL FLUIDS & ADDITIVES	None
CASING TYPE, DEPTH, SIZE	N/A
BEDROCK	16.0
DATE START	01/18/99
DATE FINISH	01/19/99
WATER LEVELS & DATES	

LITHOLOGY BY: Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	GRAPHIC LOG	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT
	CME-1	18/29"		TS	0 - 6" TOPSOIL, dark brown, roots, organics, gravel.	FILL
				FILL CL	6" - 4.0' FILL, (silty clay with gravel), approx. 25% gravel to 3", approx. 20% silt, some sand, roots and black coal-like organics, very dark grayish brown (10YR3/2), very moist, very soft (pp<.25), FILL-CL.	
	CME-2	54/60"				
				CL/CH	4.0 - 5.0' CLAY (FILL?), med. to high plasticity, dark grayish brown (10YR4/2), slightly moist to moist, firm (pp=1.75), CL/CH.	
5				CL CH	5.0 - 5.2' SILTY CLAY, (very silty) with chert piece to 2.5", color as above, very soft, moist, roots (Fill?), CL.	
					5.2 - 8.8' CLAY, color as in 4-5', med. to high plasticity, firm (pp=1.75), FeOx blebs, moist, some silt, soft, wet silty bed @ 6.7-7.1', CH.	
				CH		
	CME-3	60/60"		CH		
				CL	8.8 - 10.5' SILTY CLAY, very silty (~30%), very soft (pp<.25), very moist to wet, more abundant FeOx stain (in silt), CL.	MD ALLV.
10				CH	10.5 - 13.1' CLAY, dark grayish brown (10YR4/2), silty in first 2ft., med. to high plasticity, minor FeOx mottling in silty pockets, firm (pp=1.25), slightly moist to moist, becomes blocky with fractures with depth, CH.	
	CME-4	25/42"				
				ML	13.1 - 15.3' CLAYEY SANDY SILT, wet (saturated), very soft (pp<.25), ~30% very fine sand, ~20% clay as interbeds, FeOx blebs and stains, low plasticity, ML.	
15				CH	15.3 - 16.0' CLAY as in 10.5-13.1', moist, with 3" coarsly crystalline limestone in the shoe of sampler, CH.	
20					Auger Refusal and Total Depth @ 16.0 feet. Installed temporary well. Later abandoned and grouted to the surface with Hole Plug bentonite grout.	
					Note: Soil color is indexed on the Muncell soil color chart.	
					SINGLE WELL HYDRAULIC CONDUCTIVITY (SLUG) TEST RESULTS: K = 3E-4 cm/sec	

TEMPORARY WELL DIAGRAM

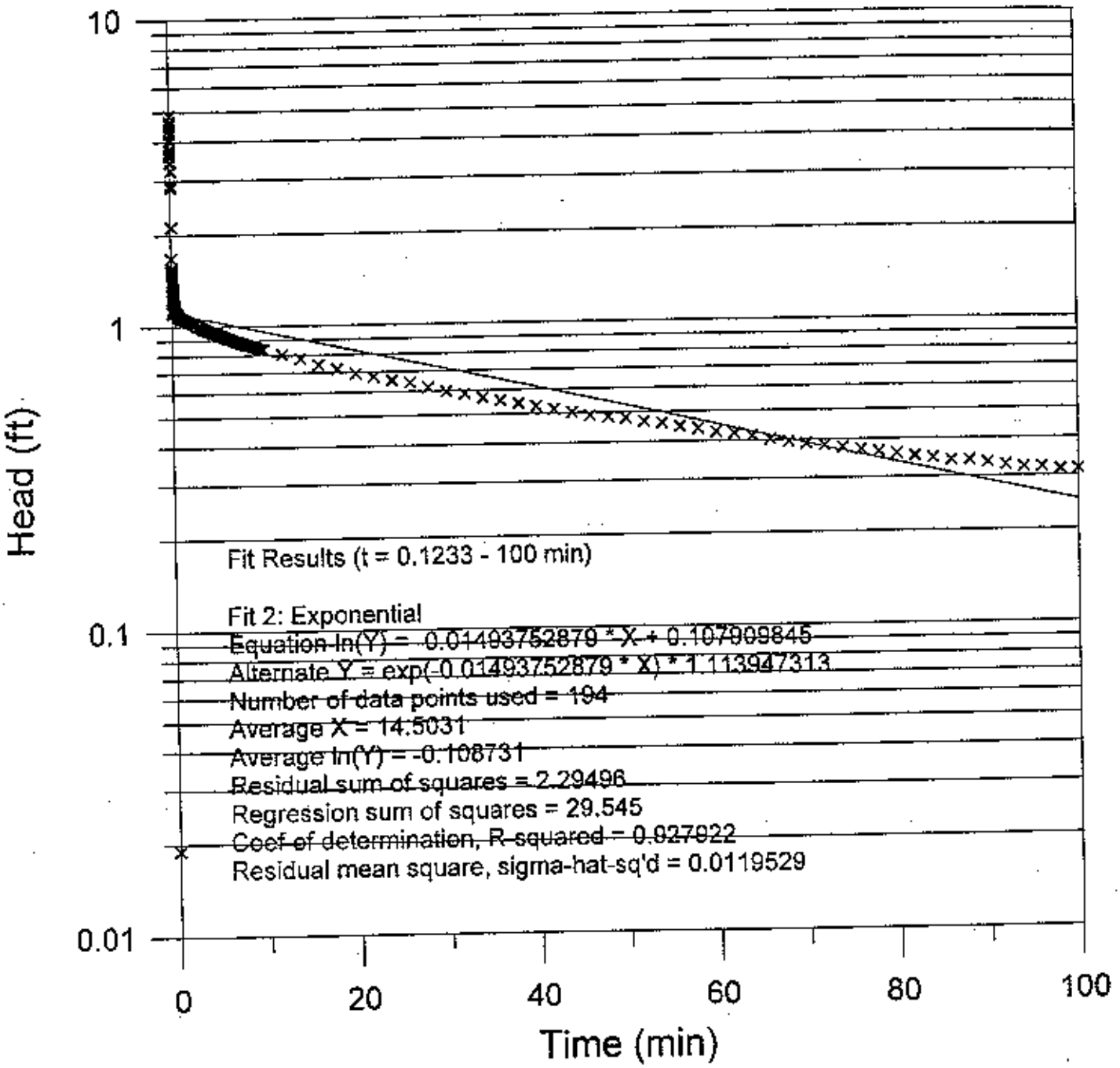


ELEVATION feet

Sample Interval | No Sample Taken | minimum | maximum | average

APPENDIX B
Slug Testing Data Sheets

SB-52 - Test 12 - falling h_2o



$r_c := \frac{2.067in}{2}$ 2" Sch 40 PVC (Driscoll, p. 987) $r_w := \frac{7.25}{2}in$ borehole radius $L := 5ft$ screen length $l := 5ft$ h_2o reservoir length

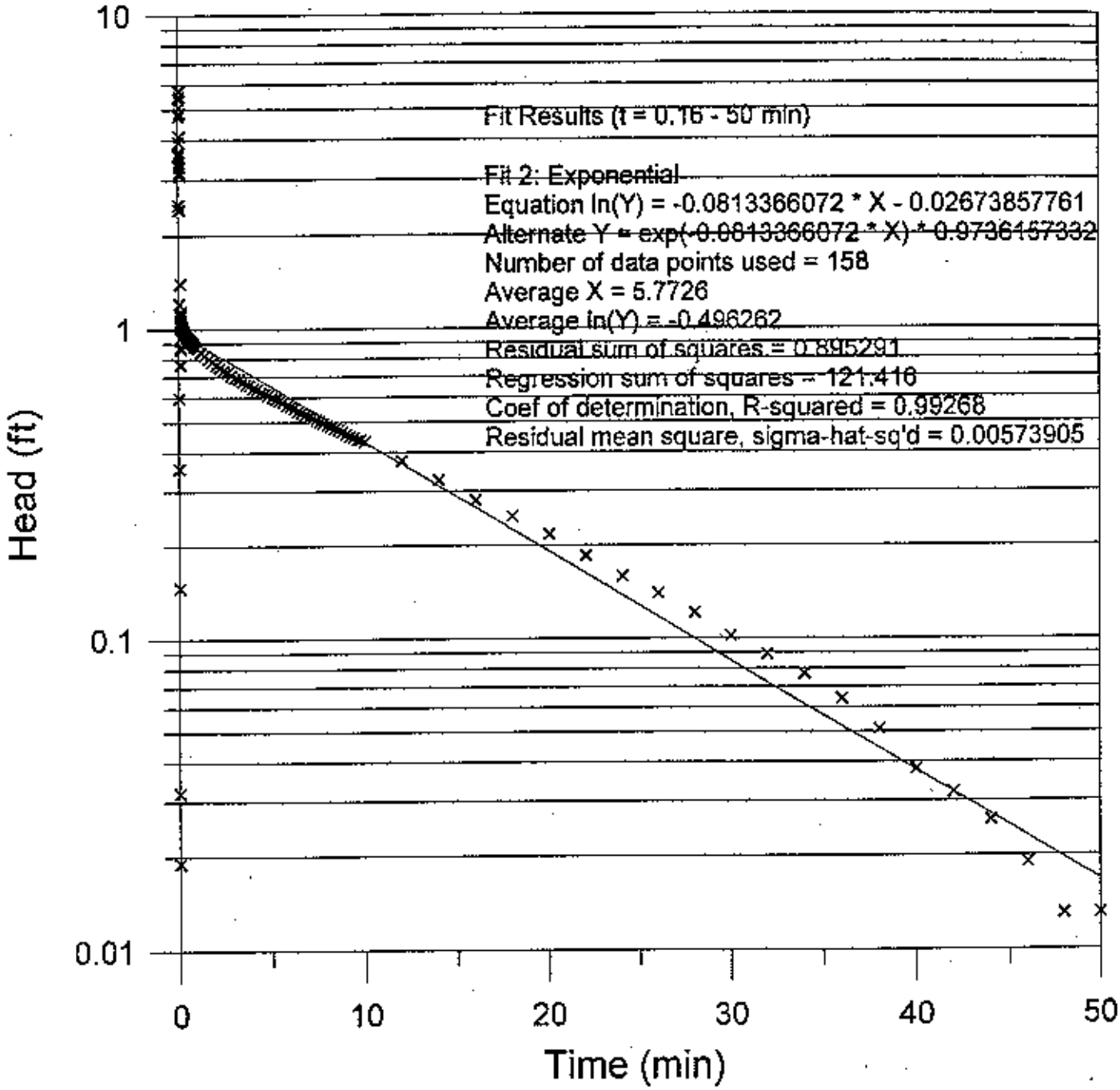
$r_s := \frac{4.026in}{2}$ reservoir radius $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 18.97ft$ $v_s := \pi \cdot r_s^2 \cdot l$ $v_s = 3.3gal$ reservoir volume

$H0c := \frac{r_s^2}{r_w^2} \cdot l$ corrected displacement $H0c = 1.54ft$ $td := 14.0ft$ $botscreen := 13.4ft$ $su := 2.2ft$ $dtw := 8.89ft$

$H := botscreen - (dtw - su)$ $H = 6.71ft$ $D := td - (dtw - su)$ $D = 7.31ft$ $S := .01493752879min^{-1}$ slope $A := 2.059$ $B := 0.313$

geometry coefficients $lnRcrw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D \to H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_w^2 \cdot lnRcrw}{2 \cdot L} \cdot S$ $K = 2.8 \cdot 10^{-4} \frac{ft}{min}$ $K = 1.4 \cdot 10^{-4} \frac{cm}{sec}$

SB-53 - Test 12 - falling h_2o



$r_c := \frac{2.067 \cdot in}{2}$ 2" Sch 40 PVC (Driscoll, p. 987) $r_w := \frac{7.25}{2} \cdot in$ borehole radius $L := 10.3 \cdot ft$ screen length $t := 5 \cdot ft$ h_2o reservoir length

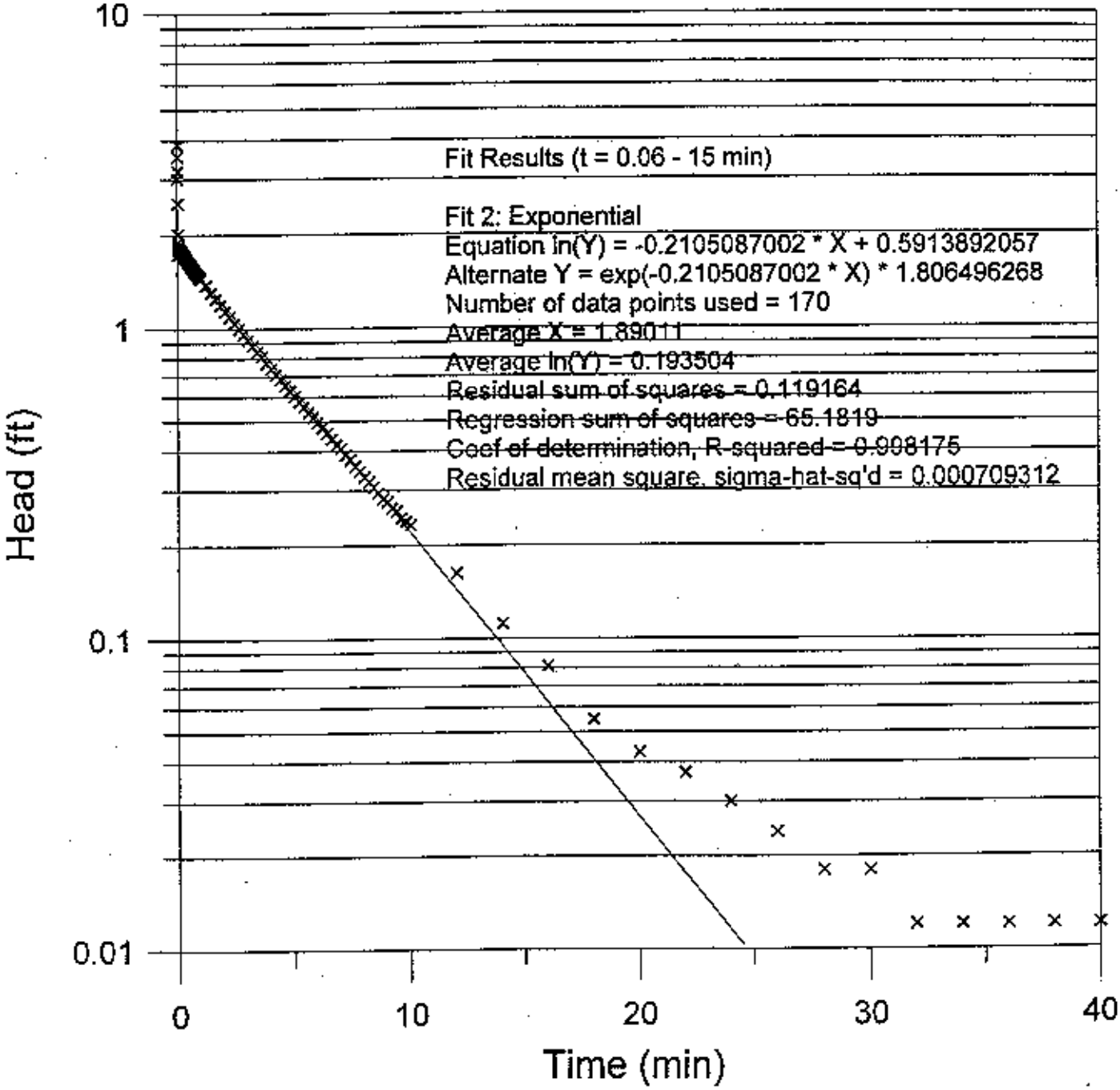
$r_s := \frac{4.026 \cdot in}{2}$ reservoir radius $H0 := \frac{r_s^2}{r_c^2} \cdot t$ displacement $H0 = 18.97 \cdot ft$ $v_s := \pi \cdot r_s^2 \cdot t$ $v_s = 3.3 \cdot gal$ reservoir volume

$H0c := \frac{r_s^2}{r_w^2} \cdot t$ corrected displacement $H0c = 1.54 \cdot ft$ $td := 18.7 \cdot ft$ $botscreen := 17.8 \cdot ft$ $su := 2.5 \cdot ft$ $dtw := 8.30 \cdot ft$

$H := botscreen - (dtw - su)$ $H = 12 \cdot ft$ $D := td - (dtw - su)$ $D = 12.9 \cdot ft$ $S := .0813366072 min^{-1}$ slope $A := 2.573$ $B := 0.419$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_w^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 9.3 \cdot 10^{-4} \frac{ft}{min}$ $K = 4.7 \cdot 10^{-4} \frac{cm}{sec}$

SB-54 - Test 6 - falling



$r_c := \frac{2.067 \cdot in}{2}$ 2" Sch 40 PVC (Driscoll, p. 987) $r_w := \frac{3.5}{2} \cdot in$ borehole radius $L := 5 \cdot ft$ screen length $l := 5.05 \cdot ft$ slug length

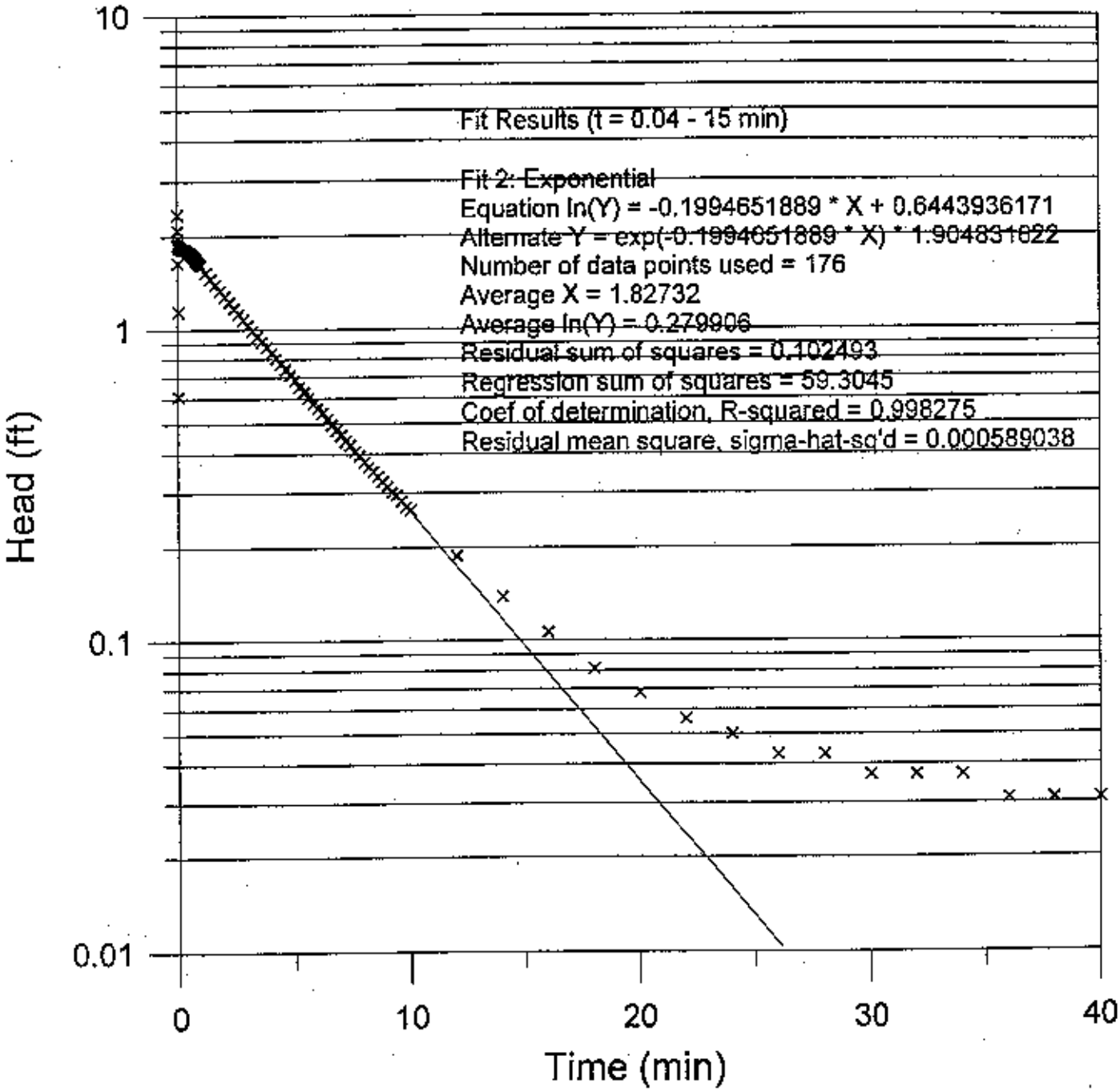
$r_s := \frac{1.25 \cdot in}{2}$ 1" PVC slug (Driscoll, p. 954) $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 1.85 \cdot ft$ $n := 0.3$ porosity $r_{cc} := \left[(1-n) \cdot r_c^2 + n \cdot r_w^2\right]^{0.5}$

$\frac{r_{cc}^2}{r_c^2} = 1.56$ $H0c := \frac{r_s^2}{r_{cc}^2} \cdot l$ corrected displacement $H0c = 1.18 \cdot ft$ $td := 33.5 \cdot ft$ $botscreen := 28.8 \cdot ft$ $su := 1.2 \cdot ft$ $dtw := 7.92 \cdot ft$

$H := botscreen - (dtw - su)$ $H = 22.08 \cdot ft$ $D := td - (dtw - su)$ $D = 26.78 \cdot ft$ $S := .2105087002 min^{-1}$ slope $A := 2.577$ $B := 0.420$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_c^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 4.6 \cdot 10^{-4} \frac{ft}{min}$ $K = 2.4 \cdot 10^{-4} \frac{cm}{sec}$

SB-54 - Test 7 - rising



$r_c := \frac{2.067 \cdot in}{2}$ 2" Sch 40 PVC (Driscoll, p. 987) $r_w := \frac{3.5}{2} \cdot in$ borehole radius $L := 5 \cdot ft$ screen length $l := 5.05 \cdot ft$ slug length

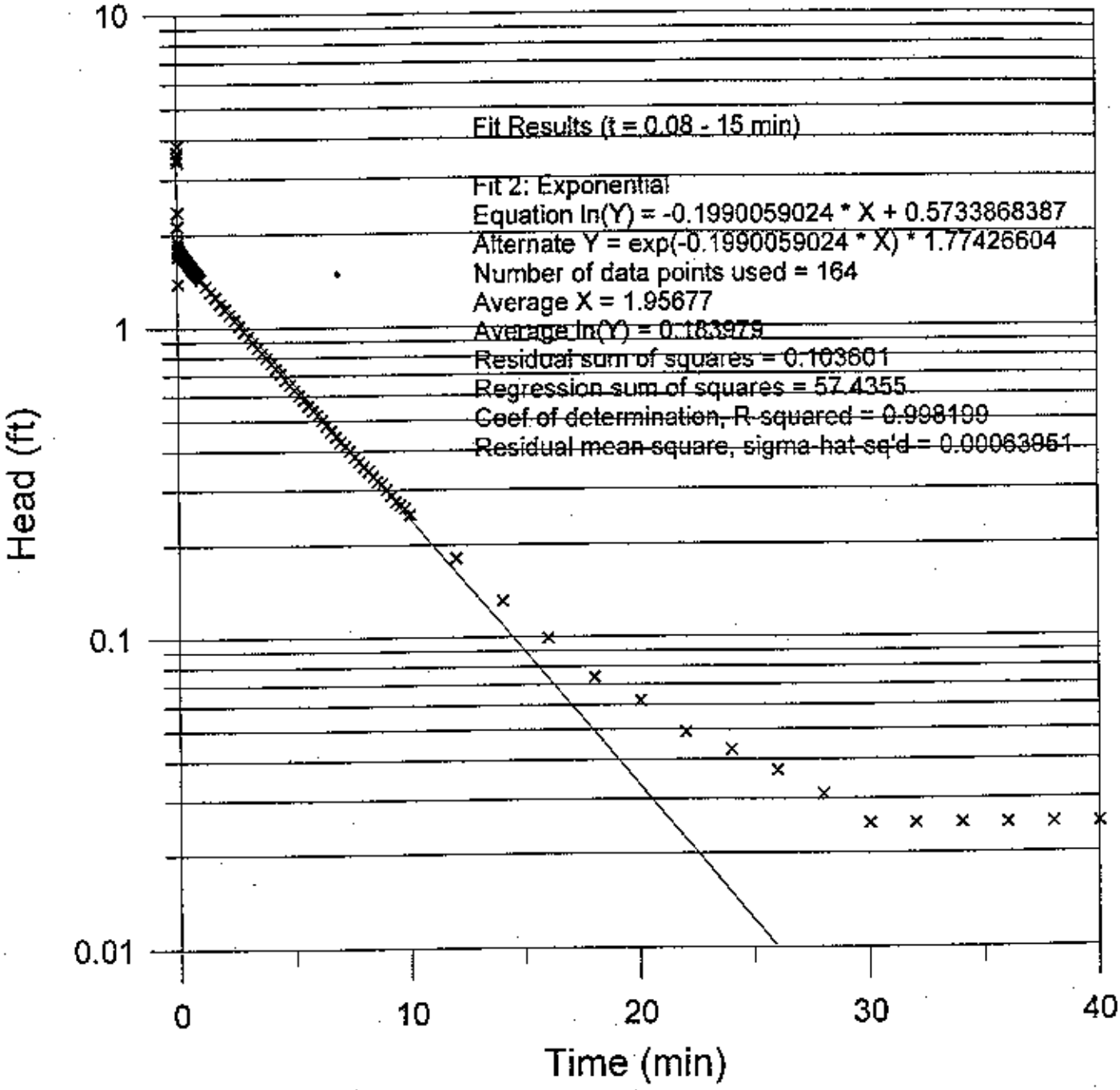
$r_s := \frac{1.25 \cdot in}{2}$ 1" PVC slug (Driscoll, p. 984) $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 1.85 \cdot ft$ $n := 0.3$ porosity $r_{cc} := \left[(1-n) \cdot r_c^2 + n \cdot r_w^2\right]^{0.5}$

$\frac{r_{cc}^2}{r_c^2} = 1.56$ $H0c := \frac{r_s^2}{r_{cc}^2} \cdot l$ corrected displacement $H0c = 1.18 \cdot ft$ $td := 33.5 \cdot ft$ $botscreen := 28.8 \cdot ft$ $su := 1.2 \cdot ft$ $dtw := 7.92 \cdot ft$

$H := botscreen - (dtw - su)$ $H = 22.08 \cdot ft$ $D := td - (dtw - su)$ $D = 26.78 \cdot ft$ $S := .1994651889 min^{-1}$ slope $A := 2.577$ $B := 0.420$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_c^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 4.4 \cdot 10^{-4} \frac{ft}{min}$ $K = 2.2 \cdot 10^{-4} \frac{cm}{sec}$

SB-54 - Test 8 - falling



$r_c := \frac{2.067 \cdot in}{2}$ 2" Sch 40 PVC (Driscoll, p. 987) $r_w := \frac{3.5}{2} \cdot in$ borehole radius $L := 5 \cdot ft$ screen length $l := 5.05 \cdot ft$ slug length

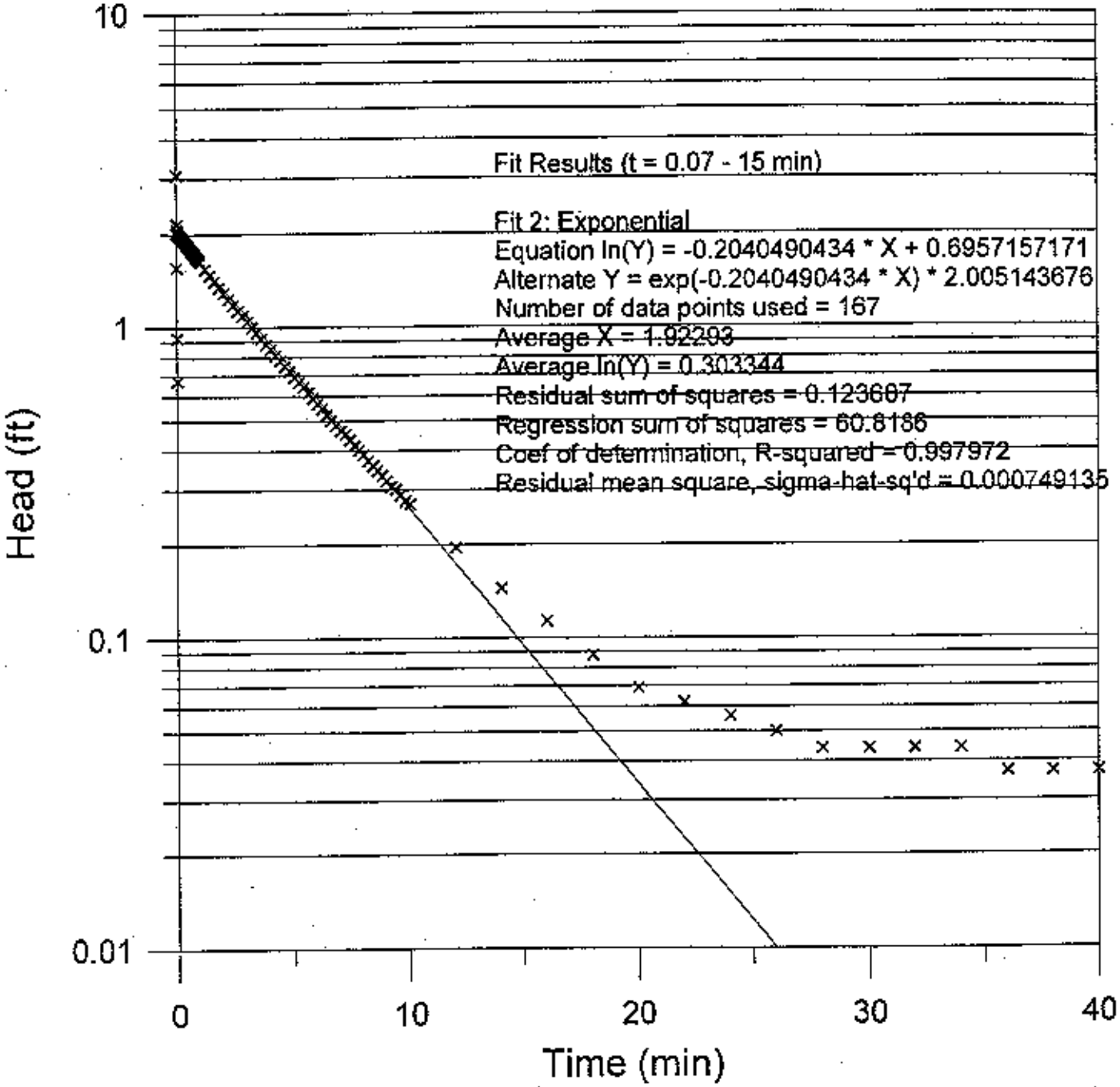
$r_s := \frac{1.25 \cdot in}{2}$ 1" PVC slug (Driscoll, p. 964) $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 1.85 \cdot ft$ $n := 0.3$ porosity $r_{cc} := \left[(1-n) \cdot r_c^2 + n \cdot r_w^2\right]^{0.5}$

$\frac{r_{cc}^2}{r_c^2} = 1.56$ $H0c := \frac{r_s^2}{r_{cc}^2} \cdot l$ corrected displacement $H0c = 1.18 \cdot ft$ $td := 33.5 \cdot ft$ $botscreen := 28.8 \cdot ft$ $su := 1.2 \cdot ft$ $dtw := 7.92 \cdot ft$

$H := botscreen - (dtw - su)$ $H = 22.08 \cdot ft$ $D := td - (dtw - su)$ $D = 26.78 \cdot ft$ $s := .1990059024 min^{-1}$ slope $A := 2.577$ $B := 0.420$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_c^2 \cdot lnRerw}{2 \cdot L} \cdot s$ $K = 4.4 \cdot 10^{-4} \frac{ft}{min}$ $K = 2.2 \cdot 10^{-4} \frac{cm}{sec}$

SB-54 - Test 9 - rising



$r_c := \frac{2.067 \cdot in}{2}$ 2" Sch 40 PVC (Driscoll, p. 987) $r_w := \frac{3.5}{2} \cdot in$ borehole radius $L := 5 \cdot ft$ screen length $l := 5.05 \cdot ft$ slug length

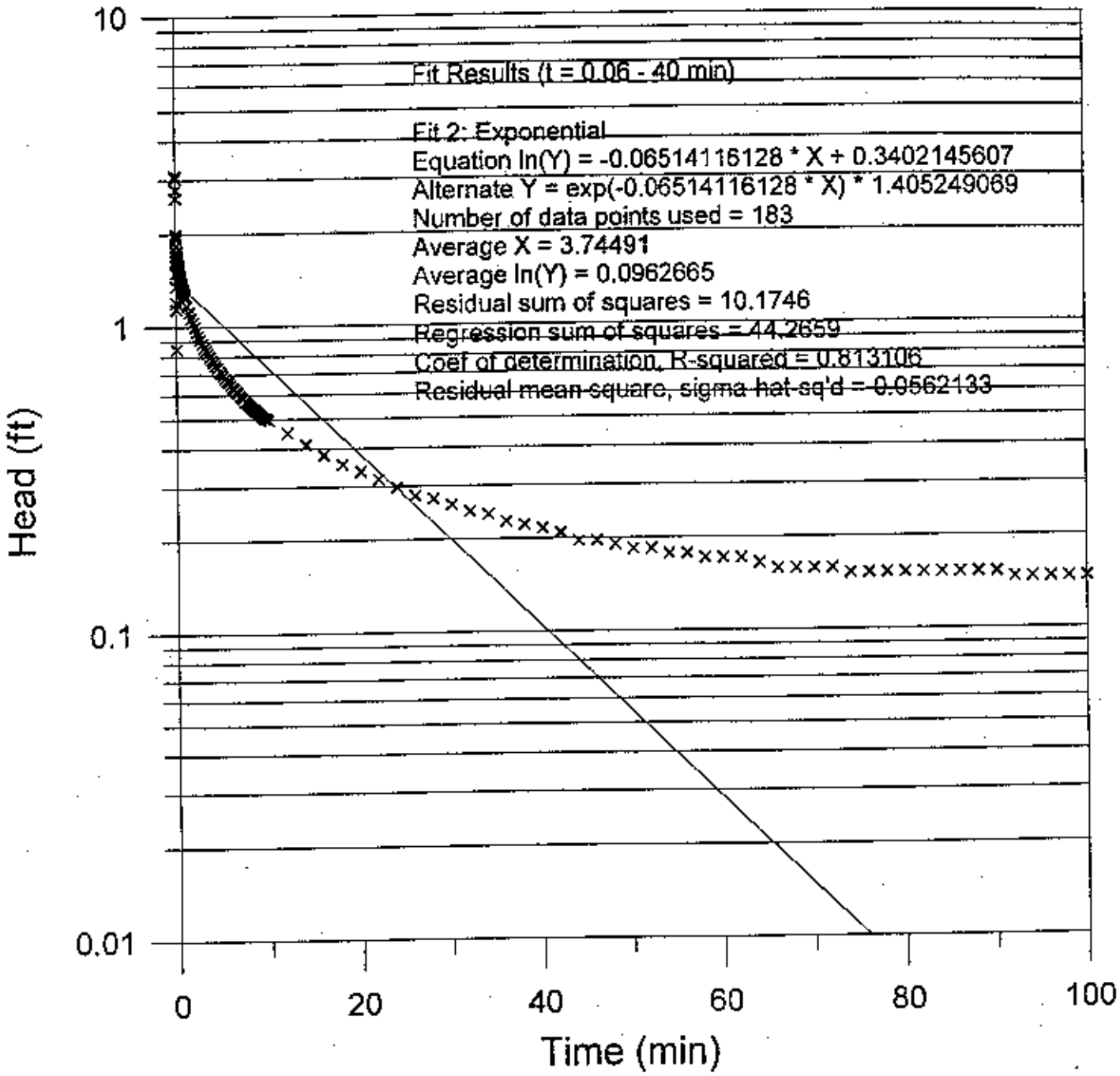
$r_s := \frac{1.25 \cdot in}{2}$ 1" PVC slug (Driscoll, p. 964) $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 1.85 \cdot ft$ $n := 0.3$ porosity $r_{cc} := \left[(1-n) \cdot r_c^2 + n \cdot r_w^2\right]^{0.5}$

$\frac{r_{cc}^2}{r_c^2} = 1.56$ $H0c := \frac{r_s^2}{r_{cc}^2} \cdot l$ corrected displacement $H0c = 1.18 \cdot ft$ $td := 33.5 \cdot ft$ $botscreen := 28.8 \cdot ft$ $su := 1.2 \cdot ft$ $dtw := 7.92 \cdot ft$

$H := botscreen - (dtw - su)$ $H = 22.08 \cdot ft$ $D := td - (dtw - su)$ $D = 26.78 \cdot ft$ $S := .2040490434 \cdot min^{-1}$ slope $A := 2.577$ $B := 0.420$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_c^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 4.5 \cdot 10^{-4} \cdot \frac{ft}{min}$ $K = 2.3 \cdot 10^{-4} \cdot \frac{cm}{sec}$

SB-55 - Test 8 - falling



$r_c := \frac{2.067 \cdot in}{2}$ 2" Sch 40 PVC (Driscoll, p. 987) $r_w := \frac{3.5}{2} \cdot in$ borehole radius $L := 5 \cdot ft$ screen length $l := 5.05 \cdot ft$ slug length

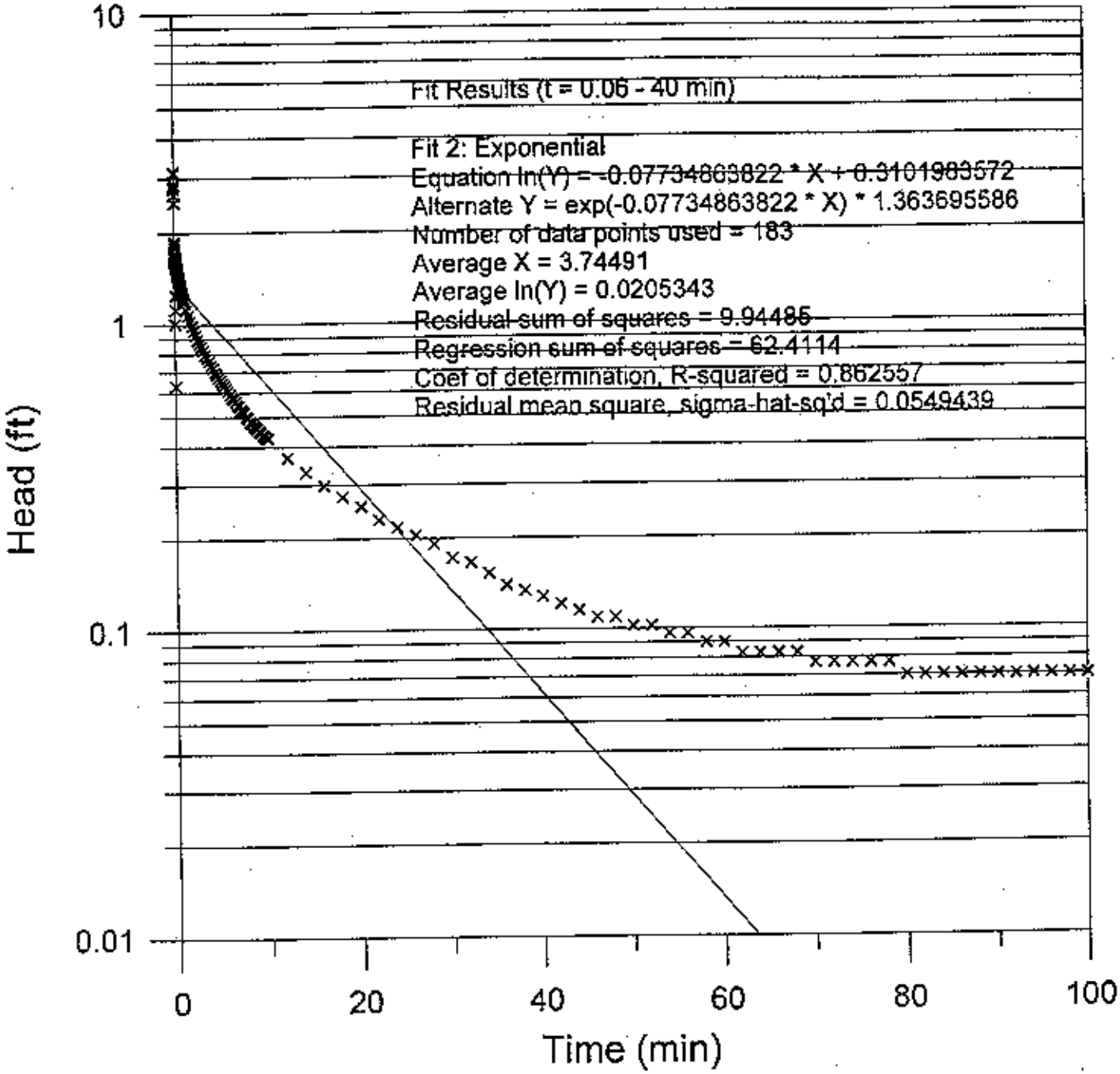
$r_s := \frac{1.25 \cdot in}{2}$ 1" PVC slug (Driscoll, p. 954) $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 1.85 \cdot ft$ $n := 0.3$ porosity $r_{cc} := \left[(1-n) \cdot r_c^2 + n \cdot r_w^2\right]^{0.5}$

$\frac{r_{cc}^2}{r_c^2} = 1.56$ $H0c := \frac{r_s^2}{r_{cc}^2} \cdot l$ corrected displacement $H0c = 1.18 \cdot ft$ $td := 27.0 \cdot ft$ $botscreen := 26.4 \cdot ft$ $su := 1.7 \cdot ft$ $dtw := 8.32 \cdot ft$

$H := botscreen - (dtw - su)$ $H = 19.78 \cdot ft$ $D := td - (dtw - su)$ $D = 20.38 \cdot ft$ $S := .06514116128 \cdot min^{-1}$ slope $A := 2.577$ $B := 0.420$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_c^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 1.5 \cdot 10^{-4} \frac{ft}{min}$ $K = 7.8 \cdot 10^{-5} \frac{cm}{sec}$

SB-55 - Test 10 - falling



$r_c := \frac{2.067 \cdot in}{2}$ 2" Sch 40 PVC (Driscoll, p. 987) $r_w := \frac{3.5}{2} \cdot in$ borehole radius $L := 5 \cdot ft$ screen length $l := 5.05 \cdot ft$ slug length

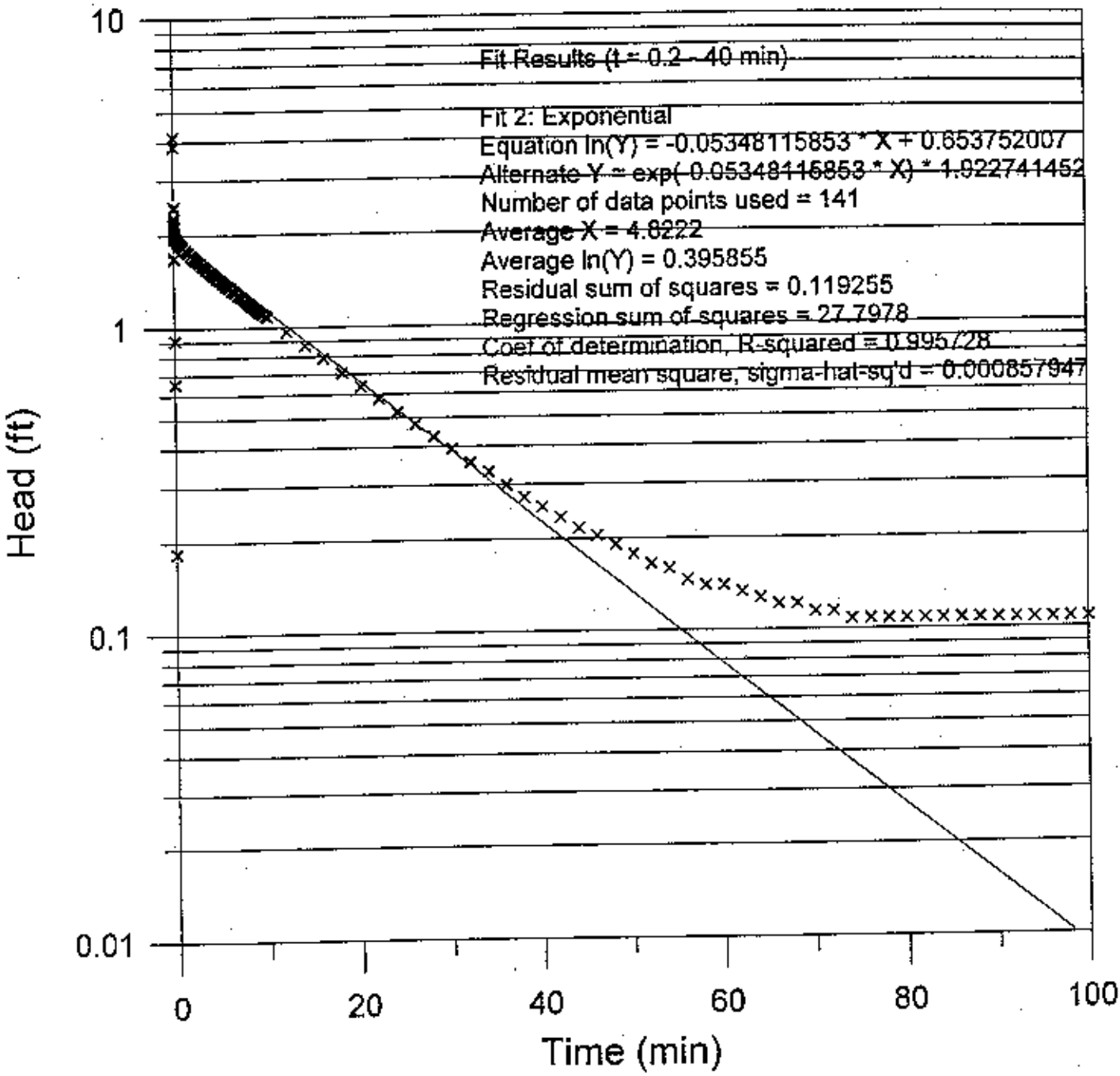
$r_s := \frac{1.25 \cdot in}{2}$ 1" PVC slug (Driscoll, p. 954) $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 1.85 \cdot ft$ $n := 0.3$ porosity $r_{cc} := \left[(1-n) \cdot r_c^2 + n \cdot r_w^2\right]^{0.5}$

$\frac{r_{cc}^2}{r_c^2} = 1.56$ $H0c := \frac{r_s^2}{r_{cc}^2} \cdot l$ corrected displacement $H0c = 1.18 \cdot ft$ $td := 27.0 \cdot ft$ $botscreen := 26.4 \cdot ft$ $su := 1.7 \cdot ft$ $dtw := 6.38 \cdot ft$

$H := botscreen - (dtw - su)$ $H = 21.72 \cdot ft$ $D := td - (dtw - su)$ $D = 22.32 \cdot ft$ $S := .07734863822 min^{-1}$ slope $A := 2.577$ $B := 0.420$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_c^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 1.8 \cdot 10^{-4} \frac{ft}{min}$ $K = 9.3 \cdot 10^{-5} \frac{cm}{sec}$

SB-55 - Test 11 - rising



$r_c := \frac{2.067 \cdot in}{2}$ 2" Sch 40 PVC (Driscoll, p. 987) $r_w := \frac{3.5}{2} \cdot in$ borehole radius $L := 5 \cdot ft$ screen length $l := 5.05 \cdot ft$ slug length

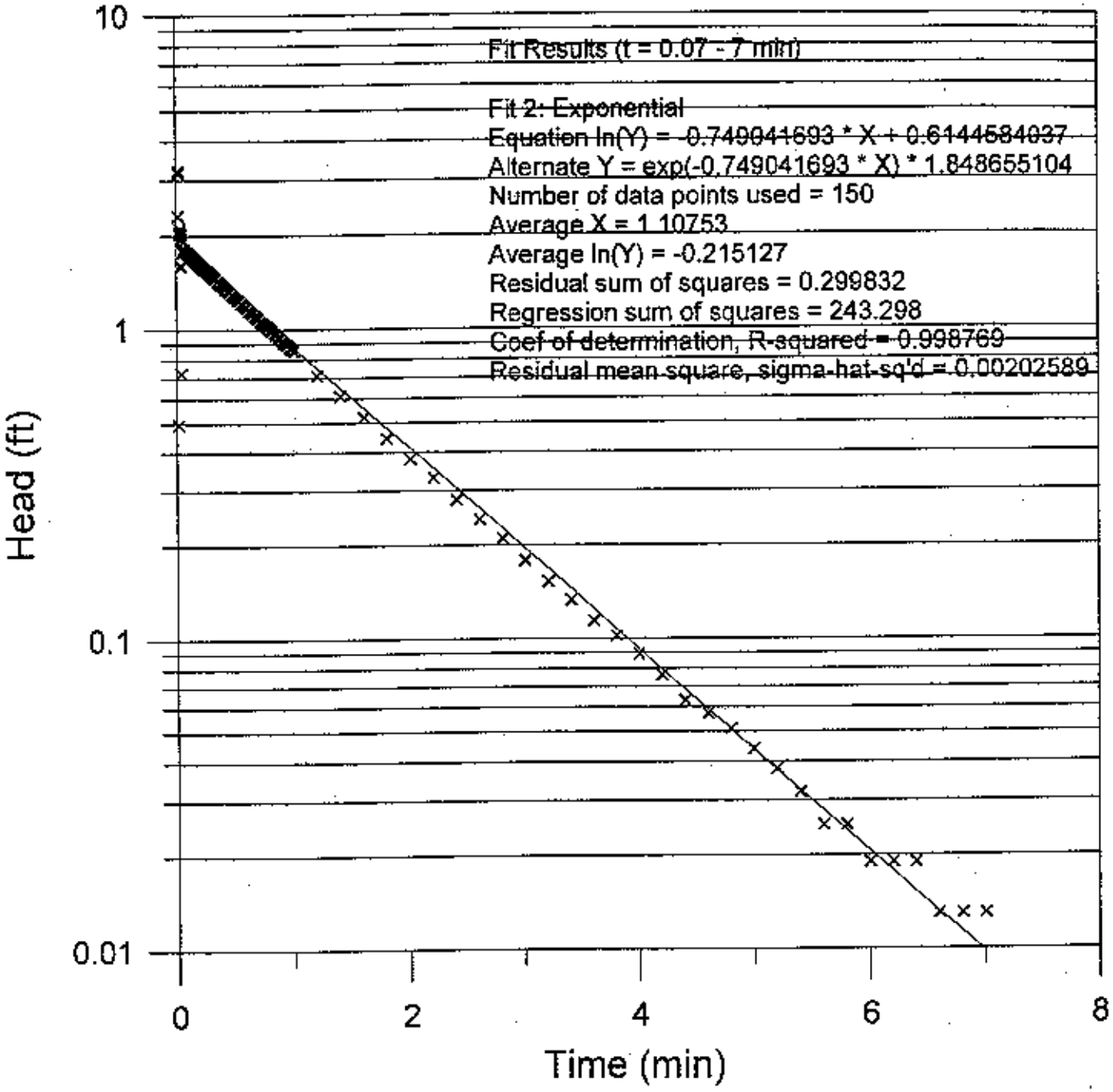
$r_s := \frac{1.25 \cdot in}{2}$ 1" PVC slug (Driscoll, p. 964) $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 1.85 \cdot ft$ $n := 0.3$ porosity $r_{cc} := \left[(1-n) \cdot r_c^2 + n \cdot r_w^2\right]^{0.5}$

$\frac{r_{cc}^2}{r_c^2} = 1.56$ $H0c := \frac{r_s^2}{r_{cc}^2} \cdot l$ corrected displacement $H0c = 1.18 \cdot ft$ $td := 27.0 \cdot ft$ $botscreen := 26.4 \cdot ft$ $su := 1.7 \cdot ft$ $dtw := 6.53 \cdot ft$

$H := botscreen - (dtw - su)$ $H = 21.57 \cdot ft$ $D := td - (dtw - su)$ $D = 22.17 \cdot ft$ $S := .05348115853 min^{-1}$ slope $A := 2.577$ $B := 0.420$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_c^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 1.3 \cdot 10^{-4} \frac{ft}{min}$ $K = 6.4 \cdot 10^{-5} \frac{cm}{sec}$

SB-58 - Test 2 - falling



$r_c := \frac{2.067 \cdot in}{2}$ 2" Sch 40 PVC (Driscoll, p. 987) $r_w := \frac{3.5}{2} \cdot in$ borehole radius $L := 5 \cdot ft$ screen length $l := 5.05 \cdot ft$ slug length

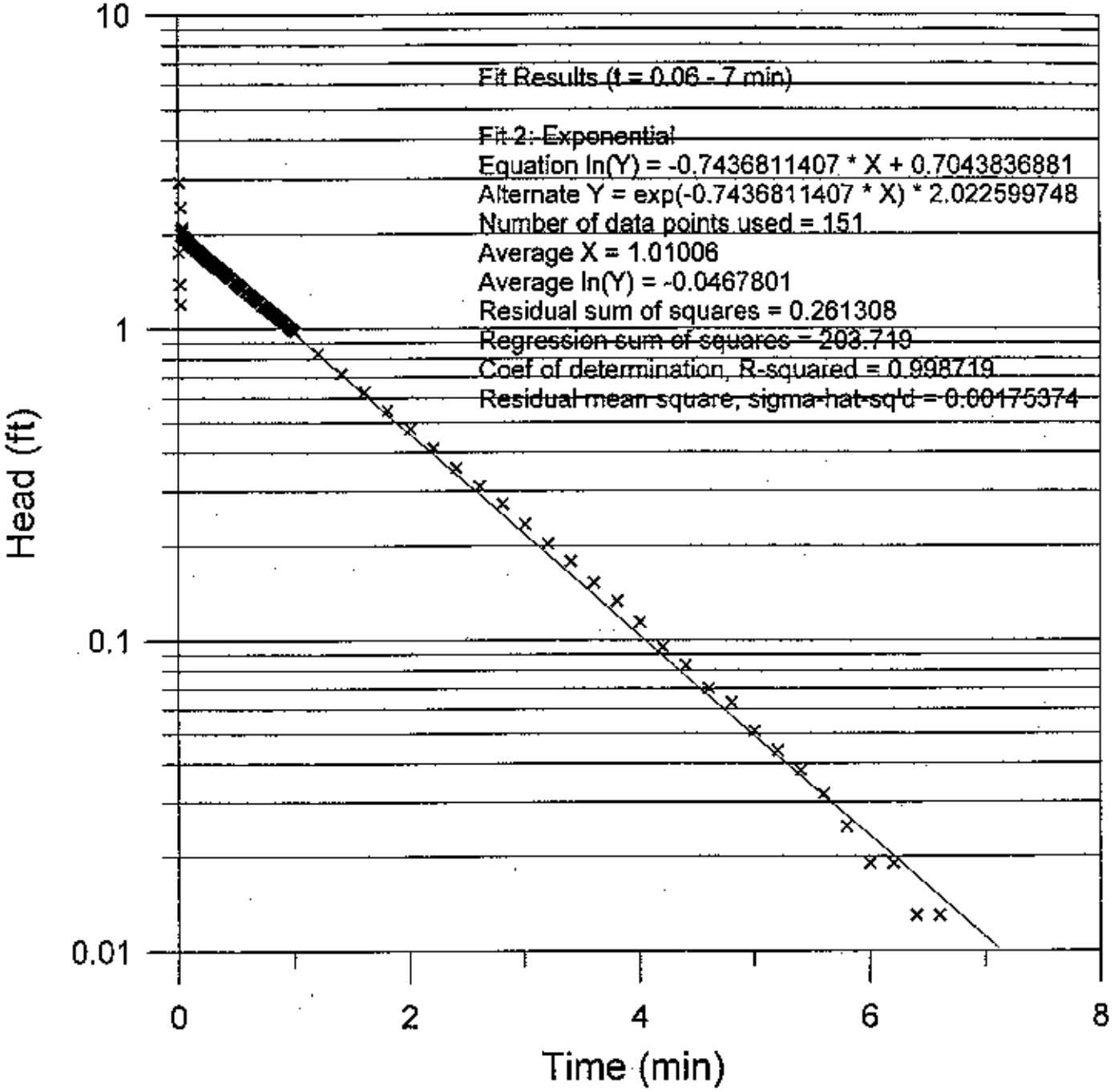
$r_s := \frac{1.25 \cdot in}{2}$ 1" PVC slug (Driscoll, p. 954) $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 1.85 \cdot ft$ $n := 0.3$ porosity $r_{cc} := \left[(1-n) \cdot r_c^2 + n \cdot r_w^2\right]^{0.5}$

$\frac{r_{cc}^2}{r_c^2} = 1.56$ $H0c := \frac{r_s^2}{r_{cc}^2} \cdot l$ corrected displacement $H0c = 1.18 \cdot ft$ $td := 26.3 \cdot ft$ $botscreen := 25.4 \cdot ft$ $su := 1.9 \cdot ft$ $dtw := 8.32 \cdot ft$

$H := botscreen - (dtw - su)$ $H = 18.98 \cdot ft$ $D := td - (dtw - su)$ $D = 19.88 \cdot ft$ $S := .749041693 min^{-1}$ slope $A := 2.577$ $B := 0.420$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_c^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 1.7 \cdot 10^{-3} \frac{ft}{min}$ $K = 8.7 \cdot 10^{-4} \frac{cm}{sec}$

SB-58 - Test 3 - rising



$r_c := \frac{2.067 \cdot in}{2}$ 2" Sch 40 PVC (Driscoll, p. 987) $r_w := \frac{3.5}{2} \cdot in$ borehole radius $L := 5 \cdot ft$ screen length $l := 5.05 \cdot ft$ slug length

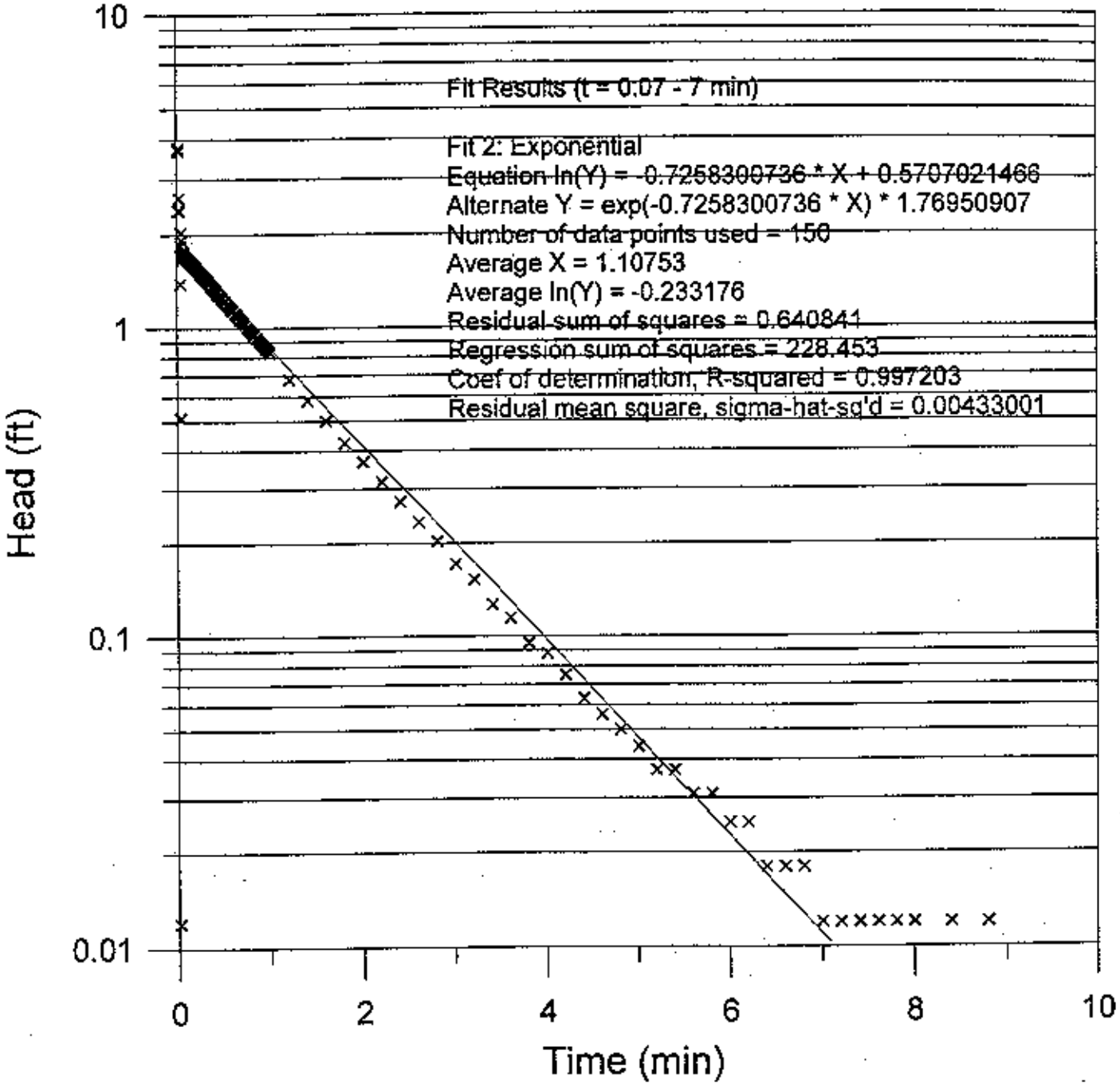
$r_s := \frac{1.25 \cdot in}{2}$ 1" PVC slug (Driscoll, p. 954) $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 1.85 \cdot ft$ $n := 0.3$ porosity $r_{cc} := \left[(1-n) \cdot r_c^2 + n \cdot r_w^2\right]^{0.5}$

$\frac{r_{cc}^2}{r_c^2} = 1.56$ $H0c := \frac{r_s^2}{r_{cc}^2} \cdot l$ corrected displacement $H0c = 1.18 \cdot ft$ $td := 26.3 \cdot ft$ $botscreen := 25.4 \cdot ft$ $su := 1.9 \cdot ft$ $dtw := 8.32 \cdot ft$

$H := botscreen - (dtw - su)$ $H = 18.98 \cdot ft$ $D := td - (dtw - su)$ $D = 19.88 \cdot ft$ $S := .7436811407 min^{-1}$ slope $A := 2.577$ $B := 0.420$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_c^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 1.7 \cdot 10^{-3} \frac{ft}{min}$ $K = 8.7 \cdot 10^{-4} \frac{cm}{sec}$

SB-58 - Test 4 - falling



$r_c := \frac{2.067 \cdot in}{2}$ 2" Sch 40 PVC (Driscoll, p. 987) $r_w := \frac{3.5}{2} \cdot in$ borehole radius $L := 5 \cdot ft$ screen length $t := 5.05 \cdot ft$ slug length

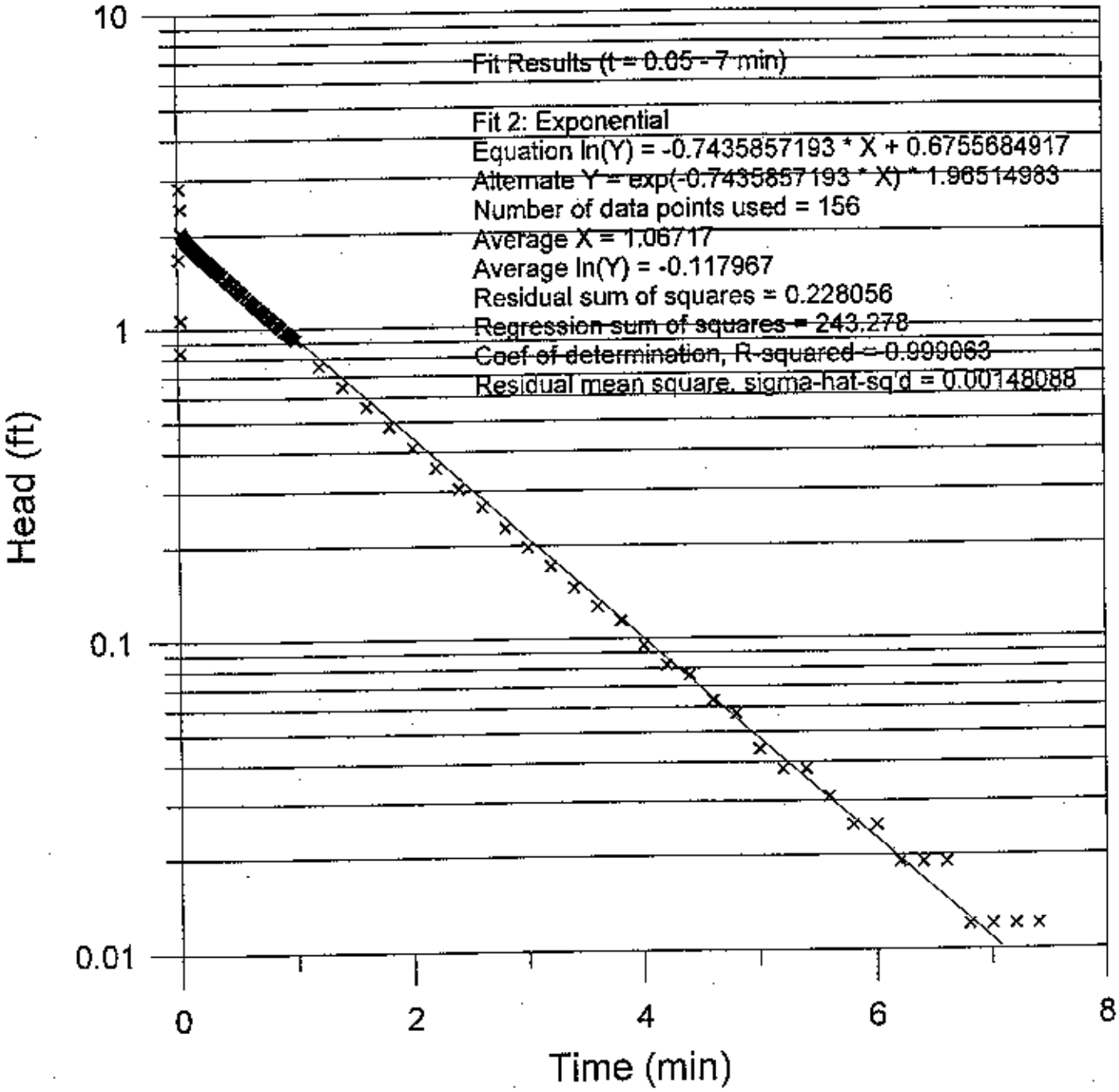
$r_s := \frac{1.25 \cdot in}{2}$ 1" PVC slug (Driscoll, p. 954) $H0 := \frac{r_s^2}{r_c^2} \cdot t$ displacement $H0 = 1.85 \cdot ft$ $n := 0.3$ porosity $r_{ce} := \left[(1-n) \cdot r_c^2 + n \cdot r_w^2\right]^{0.5}$

$\frac{r_{ce}^2}{r_c^2} = 1.56$ $H0c := \frac{r_s^2}{r_{ce}^2} \cdot t$ corrected displacement $H0c = 1.18 \cdot ft$ $td := 26.3 \cdot ft$ $botscreen := 25.4 \cdot ft$ $su := 1.9 \cdot ft$ $dtw := 8.32 \cdot ft$

$H := botscreen - (dtw - su)$ $H = 18.98 \cdot ft$ $D := td - (dtw - su)$ $D = 19.88 \cdot ft$ $S := .7258300736 min^{-1}$ slope $A := 2.577$ $B := 0.420$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_c^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 1.7 \cdot 10^{-3} \frac{ft}{min}$ $K = 8.5 \cdot 10^{-4} \frac{cm}{sec}$

SB-58 - Test 5 - rising



$r_c := \frac{2.067 \cdot in}{2}$ 2" Sch 40 PVC (Driscoll, p. 987) $r_w := \frac{3.5}{2} \cdot in$ borehole radius $L := 5 \cdot ft$ screen length $l := 5.05 \cdot ft$ slug length

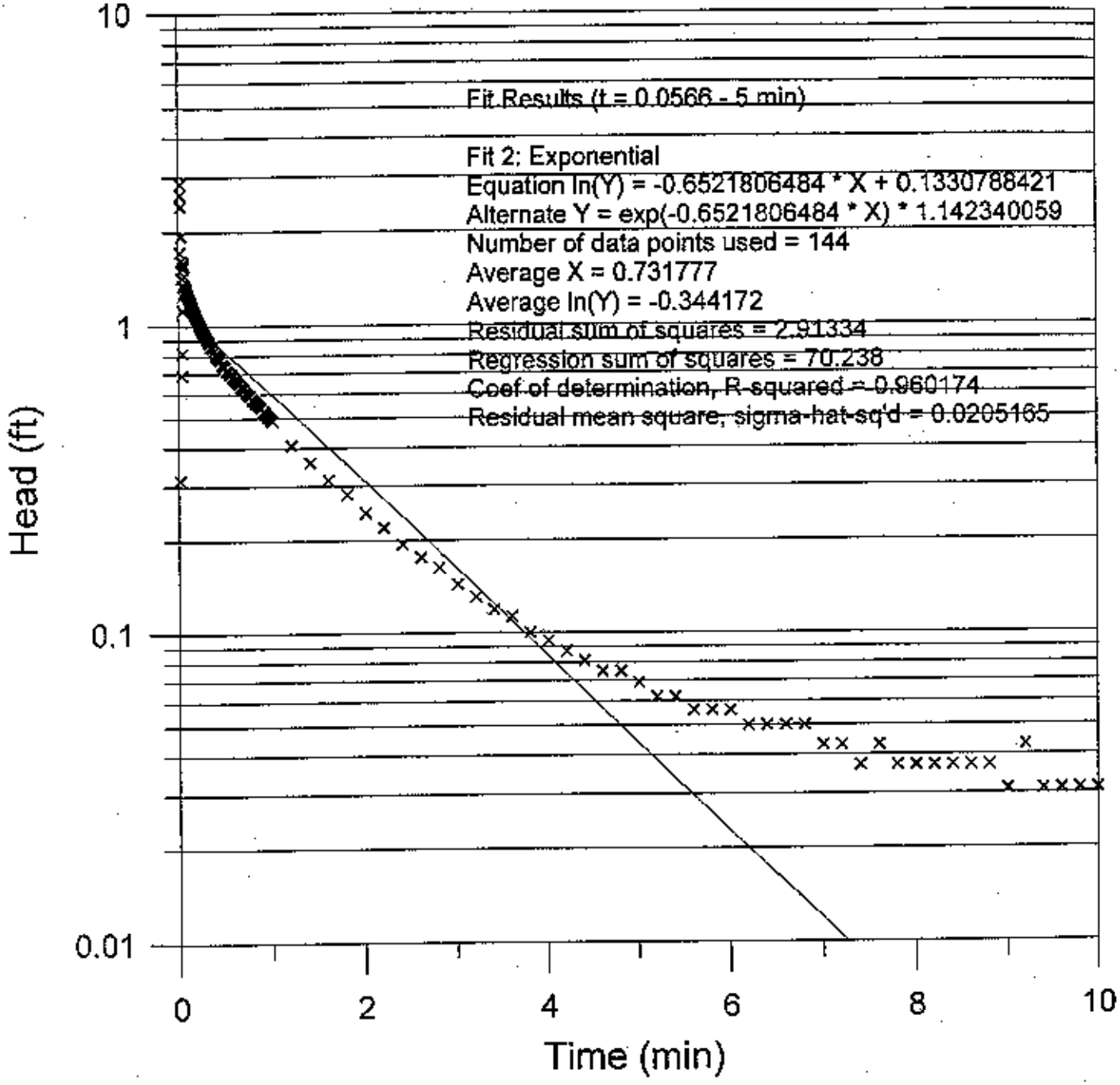
$r_s := \frac{1.25 \cdot in}{2}$ 1" PVC slug (Driscoll, p. 954) $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 1.85 \cdot ft$ $n := 0.3$ porosity $r_{cc} := \left[(1-n) \cdot r_c^2 + n \cdot r_w^2\right]^{0.5}$

$\frac{r_{cc}^2}{r_c^2} = 1.56$ $H0c := \frac{r_s^2}{r_{cc}^2} \cdot l$ corrected displacement $H0c = 1.18 \cdot ft$ $td := 26.3 \cdot ft$ $botscreen := 25.4 \cdot ft$ $su := 1.9 \cdot ft$ $dtw := 8.32 \cdot ft$

$H := botscreen - (dtw - su)$ $H = 18.98 \cdot ft$ $D := td - (dtw - su)$ $D = 19.88 \cdot ft$ $S := .7435857193 min^{-1}$ slope $A := 2.577$ $B := 0.420$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_c^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 1.7 \cdot 10^{-3} \frac{ft}{min}$ $K = 8.7 \cdot 10^{-4} \frac{cm}{sec}$

SB-59 - Test 2 - falling



$r_c := \frac{2.067 \cdot in}{2}$ 2" Sch 40 PVC (Driscoll, p. 987) $r_w := \frac{3.5}{2} \cdot in$ borehole radius $L := 10.3 \cdot ft$ screen length $l := 5.05 \cdot ft$ slug length

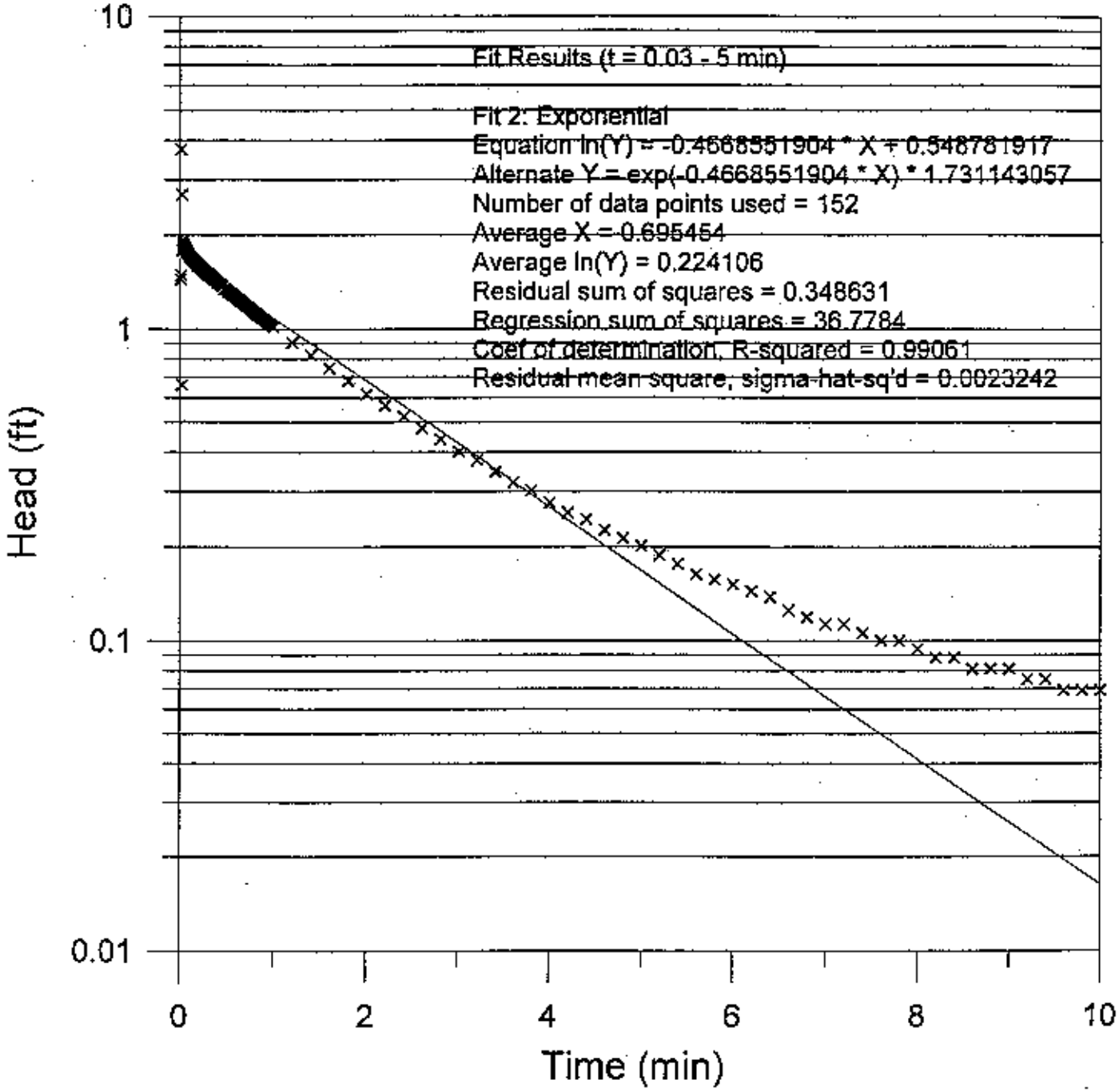
$r_s := \frac{1.25 \cdot in}{2}$ 1" PVC slug (Driscoll, p. 954) $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 1.85 \cdot ft$ $n := 0.3$ porosity $r_{cc} := \left[(1-n) \cdot r_c^2 + n \cdot r_w^2\right]^{0.5}$

$\frac{r_{cc}^2}{r_c^2} = 1.56$ $H0c := \frac{r_s^2}{r_{cc}^2} \cdot l$ corrected displacement $H0c = 1.18 \cdot ft$ $td := 22.5 \cdot ft$ $botscreen := 21.0 \cdot ft$ $su := 2 \cdot ft$ $dtw := 6.63 \cdot ft$

$H := botscreen - (dtw - su)$ $H = 16.37 \cdot ft$ $D := td - (dtw - su)$ $D = 17.87 \cdot ft$ $S := .6521806484 min^{-1}$ slope $A := 3.679$ $B := 0.586$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_c^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 7.7 \cdot 10^{-4} \frac{ft}{min}$ $K = 3.9 \cdot 10^{-4} \frac{cm}{sec}$

SB-59 - Test 3 - rising



$r_c := \frac{2.067 \cdot in}{2}$ 2" Sch 40 PVC (Driscoll, p. 987) $r_w := \frac{3.5}{2} \cdot in$ borehole radius $L := 10.3 \cdot ft$ screen length $l := 5.05 \cdot ft$ slug length

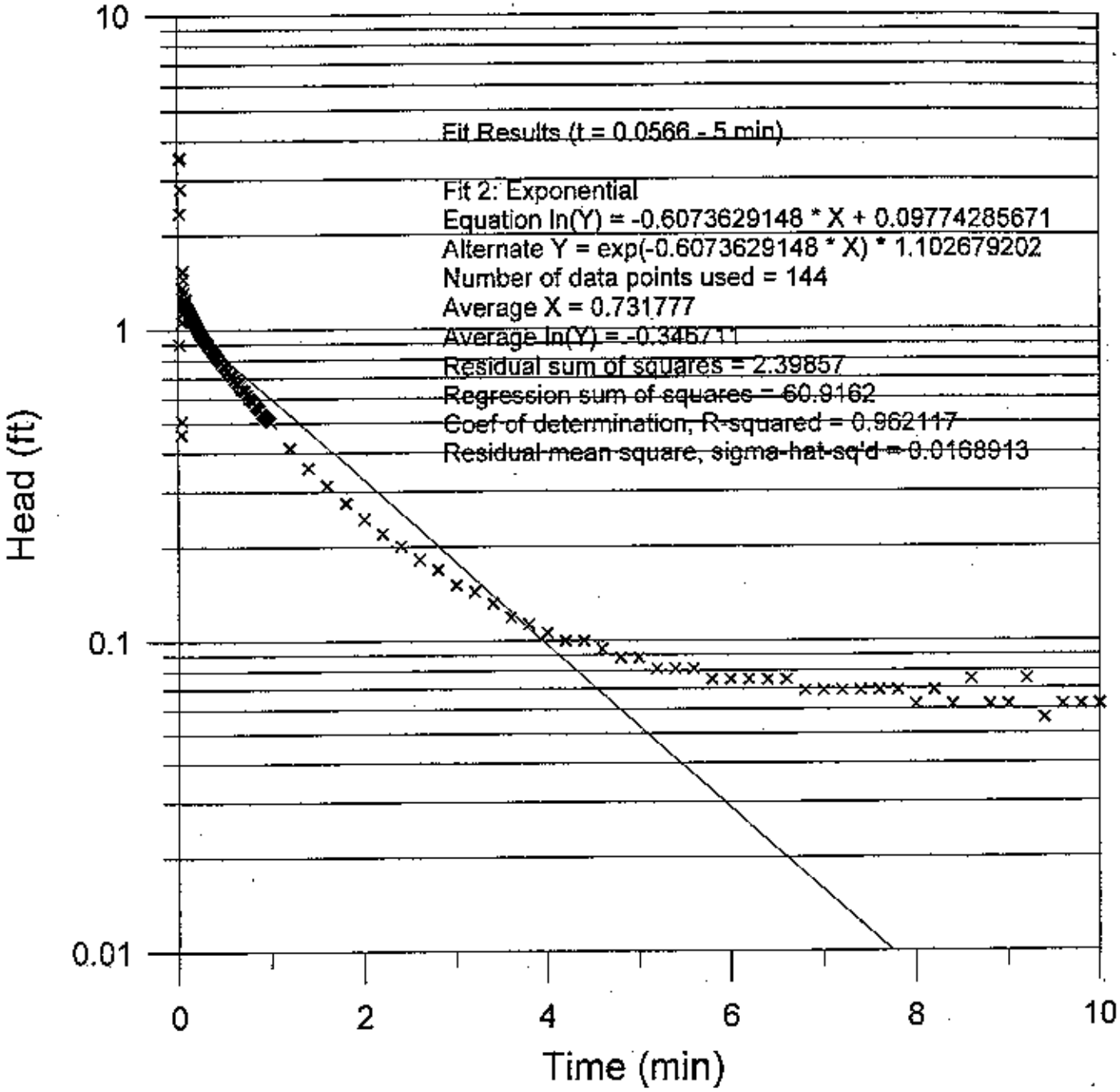
$r_s := \frac{1.25 \cdot in}{2}$ 1" PVC slug (Driscoll, p. 954) $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 1.85 \cdot ft$ $n := 0.3$ porosity $r_{cc} := \left[(1-n) \cdot r_c^2 + n \cdot r_w^2\right]^{0.5}$

$\frac{r_{cc}^2}{r_c^2} = 1.56$ $H0c := \frac{r_s^2}{r_{cc}^2} \cdot l$ corrected displacement $H0c = 1.18 \cdot ft$ $td := 22.5 \cdot ft$ $botscreen := 21.0 \cdot ft$ $su := 2 \cdot ft$ $dtw := 6.63 \cdot ft$

$H := botscreen - (dtw - su)$ $H = 16.37 \cdot ft$ $D := td - (dtw - su)$ $D = 17.87 \cdot ft$ $S := .4668551904 min^{-1}$ slope $A := 3.679$ $B := 0.586$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_c^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 5.5 \cdot 10^{-4} \frac{ft}{min}$ $K = 2.8 \cdot 10^{-4} \frac{cm}{sec}$

SB-59 - Test 4 - falling



$r_c := \frac{2.067 \cdot in}{2}$ 2" Sch 40 PVC (Driscoll, p. 987) $r_w := \frac{3.5}{2} \cdot in$ borehole radius $L := 10.3 \cdot ft$ screen length $l := 5.05 \cdot ft$ slug length

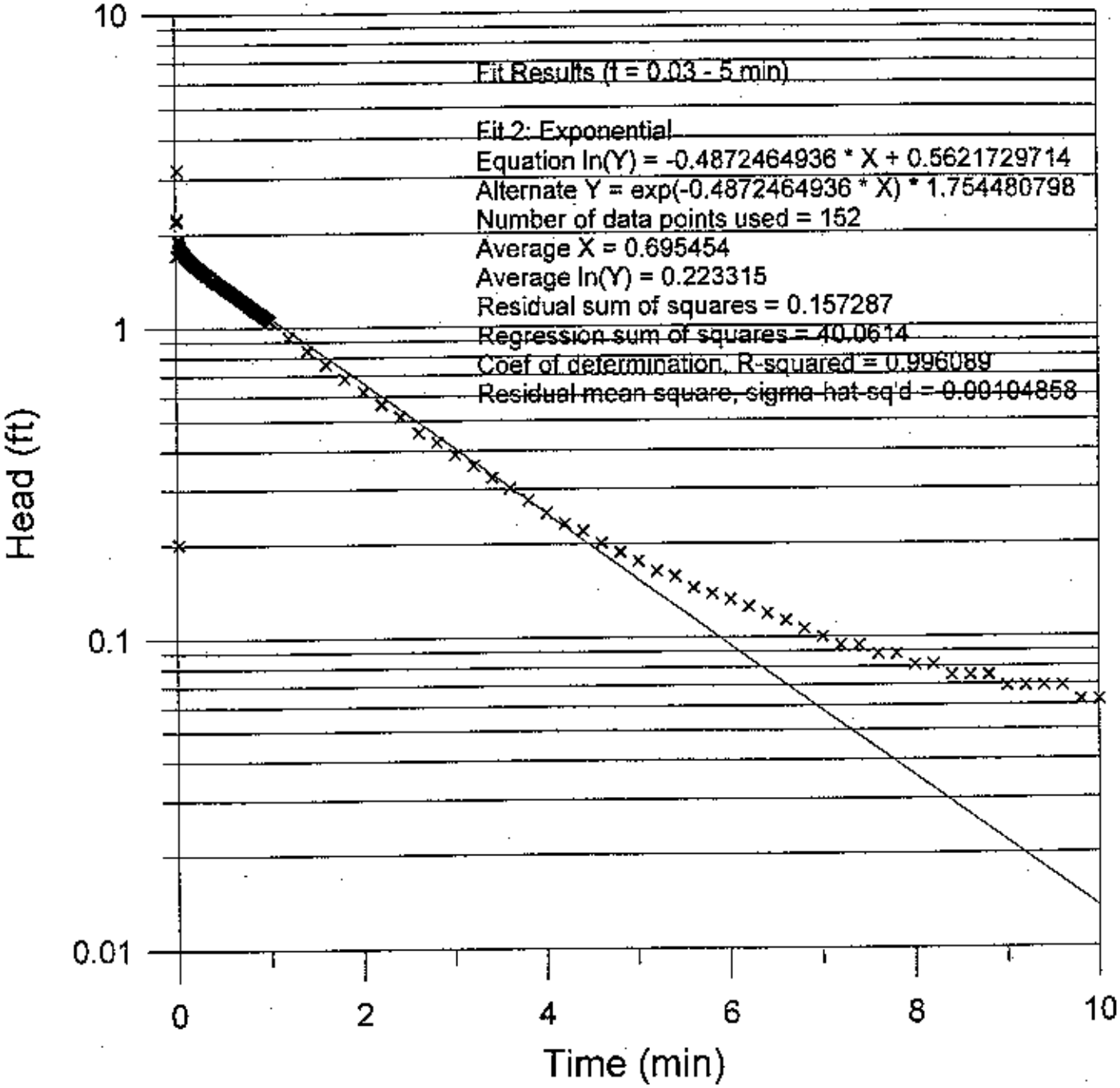
$r_s := \frac{1.25 \cdot in}{2}$ 1" PVC slug (Driscoll, p. 954) $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 1.85 \cdot ft$ $n := 0.3$ porosity $r_{cc} := \left[(1-n) \cdot r_c^2 + n \cdot r_w^2\right]^{0.5}$

$\frac{r_{cc}^2}{r_c^2} = 1.56$ $H0c := \frac{r_s^2}{r_{cc}^2} \cdot l$ corrected displacement $H0c = 1.18 \cdot ft$ $td := 22.5 \cdot ft$ $botscreen := 21.0 \cdot ft$ $su := 2 \cdot ft$ $dtw := 6.63 \cdot ft$

$H := botscreen - (dtw - su)$ $H = 16.37 \cdot ft$ $D := td - (dtw - su)$ $D = 17.87 \cdot ft$ $S := .6073629148 min^{-1}$ slope $A := 3.679$ $B := 0.586$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_c^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 7.2 \cdot 10^{-4} \frac{ft}{min}$ $K = 3.6 \cdot 10^{-4} \frac{cm}{sec}$

SB-59 - Test 5 - rising



$r_c := \frac{2.067 \cdot in}{2}$ 2" Sch 40 PVC (Driscoll, p. 987) $r_w := \frac{3.5}{2} \cdot in$ borehole radius $L := 10.3 \cdot ft$ screen length $l := 5.05 \cdot ft$ slug length

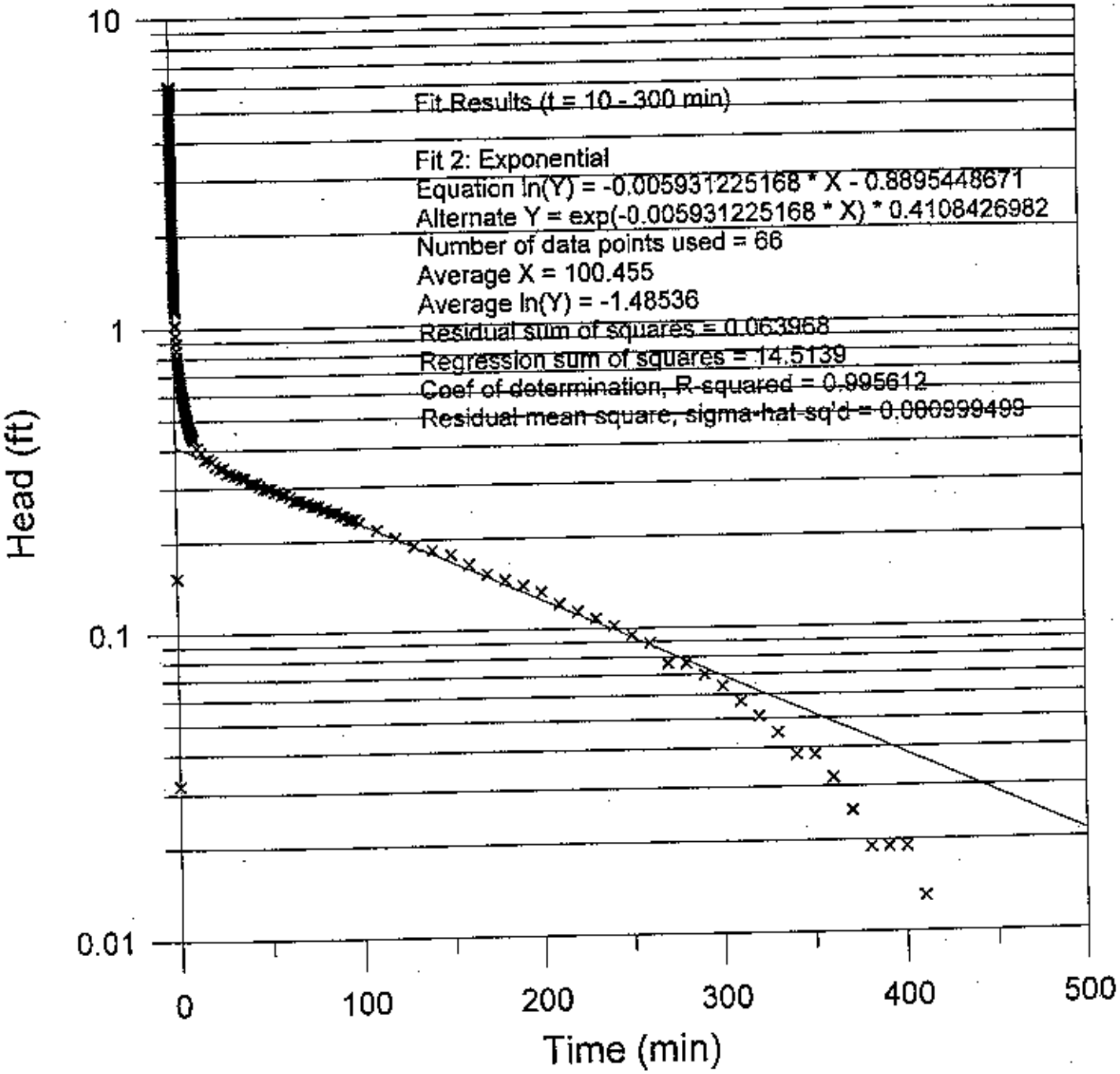
$r_s := \frac{1.25 \cdot in}{2}$ 1" PVC slug (Driscoll, p. 954) $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 1.85 \cdot ft$ $n := 0.3$ porosity $r_{cc} := \left[(1-n) \cdot r_c^2 + n \cdot r_w^2\right]^{0.5}$

$\frac{r_{cc}^2}{r_c^2} = 1.56$ $H0c := \frac{r_s^2}{r_{cc}^2} \cdot l$ corrected displacement $H0c = 1.18 \cdot ft$ $td := 22.5 \cdot ft$ $botscreen := 21.0 \cdot ft$ $su := 2 \cdot ft$ $dtw := 6.63 \cdot ft$

$H := botscreen - (dtw - su)$ $H = 16.37 \cdot ft$ $D := td - (dtw - su)$ $D = 17.87 \cdot ft$ $S := .4872464936 \cdot min^{-1}$ slope $A := 3.679$ $B := 0.586$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_c^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 5.8 \cdot 10^{-4} \frac{ft}{min}$ $K = 2.9 \cdot 10^{-4} \frac{cm}{sec}$

SB-61 - Test 13 - falling h_2o



$r_c := \frac{2.067 \cdot in}{2}$ 2" Sch 40 PVC (Driscoll, p. 987) $r_w := \frac{7.25}{2} \cdot in$ borehole radius $L := 5 \cdot ft$ screen length $l := 2.5 \cdot ft$ $h_2 0$ reservoir length

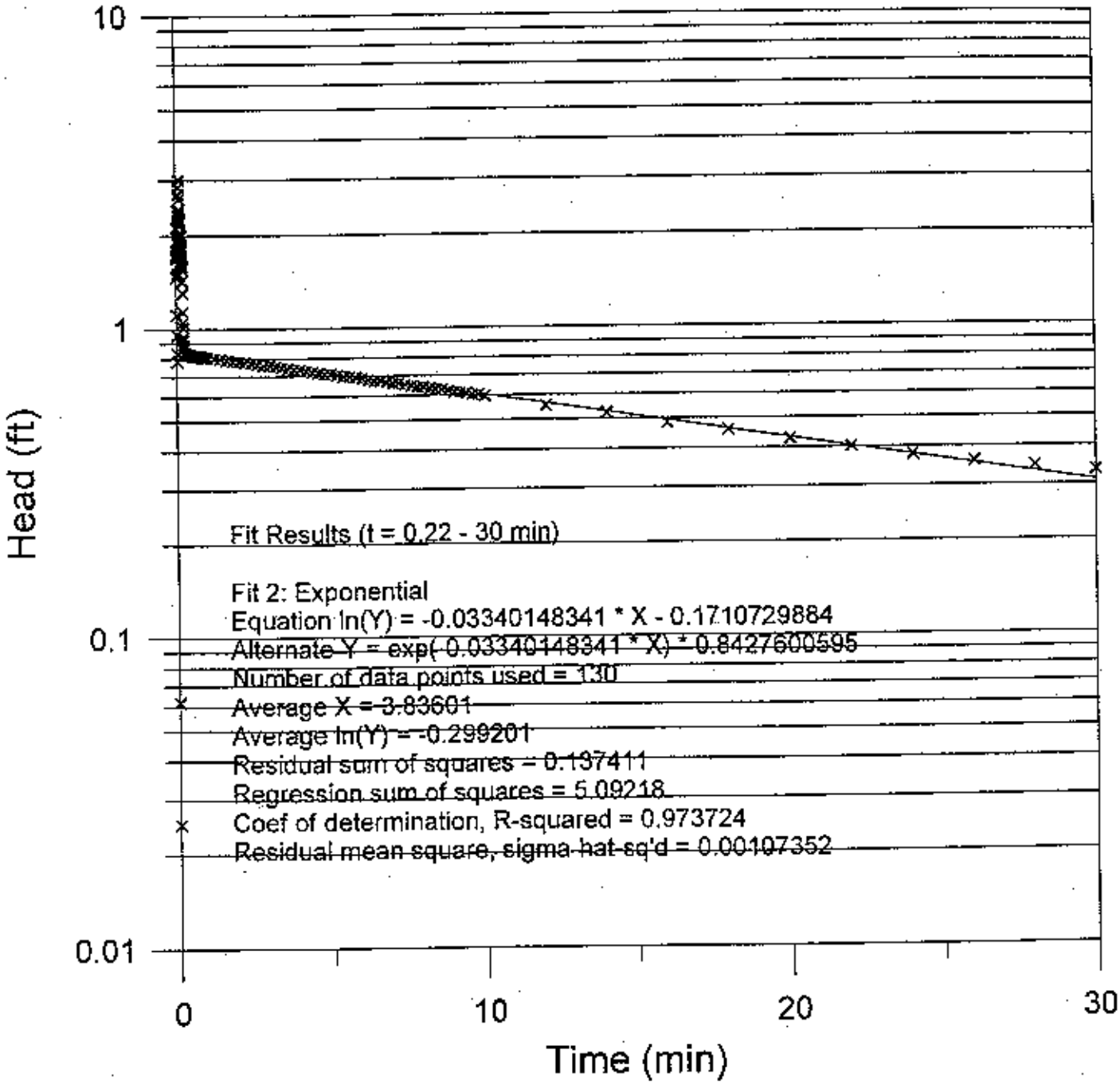
$r_s := \frac{4.026 in}{2}$ reservoir radius $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 9.48 \cdot ft$ $v_s := \pi \cdot r_s^2 \cdot l$ $v_s = 1.7 \cdot gal$ reservoir volume

$H0c := \frac{r_s^2}{r_w^2} \cdot l$ corrected displacement $H0c = 0.77 \cdot ft$ $td := 13.5 \cdot ft$ botscreen $:= 13.0 \cdot ft$ $su := 2.0 \cdot ft$ $dtw := 8.80 \cdot ft$

$H := botscreen - (dtw - su)$ $H = 6.2 \cdot ft$ $D := td - (dtw - su)$ $D = 6.7 \cdot ft$ $S := .005931225168 min^{-1}$ slope $A := 2.059$ $B := 0.313$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)} \right]^{-1}$ partially penetrating case $K := \frac{r_w^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 1.1 \cdot 10^{-4} \frac{ft}{min}$ $K = 5.5 \cdot 10^{-5} \frac{cm}{sec}$

SB-62 - Test 13 - falling h_2o



$r_c := \frac{2.067 \cdot in}{2}$ 2" Sch 40 PVC (Driscoll, p. 967) $r_w := \frac{7.25}{2} \cdot in$ borehole radius $L := 5 \cdot ft$ screen length $l := 5 \cdot ft$ $h_2 0$ reservoir length

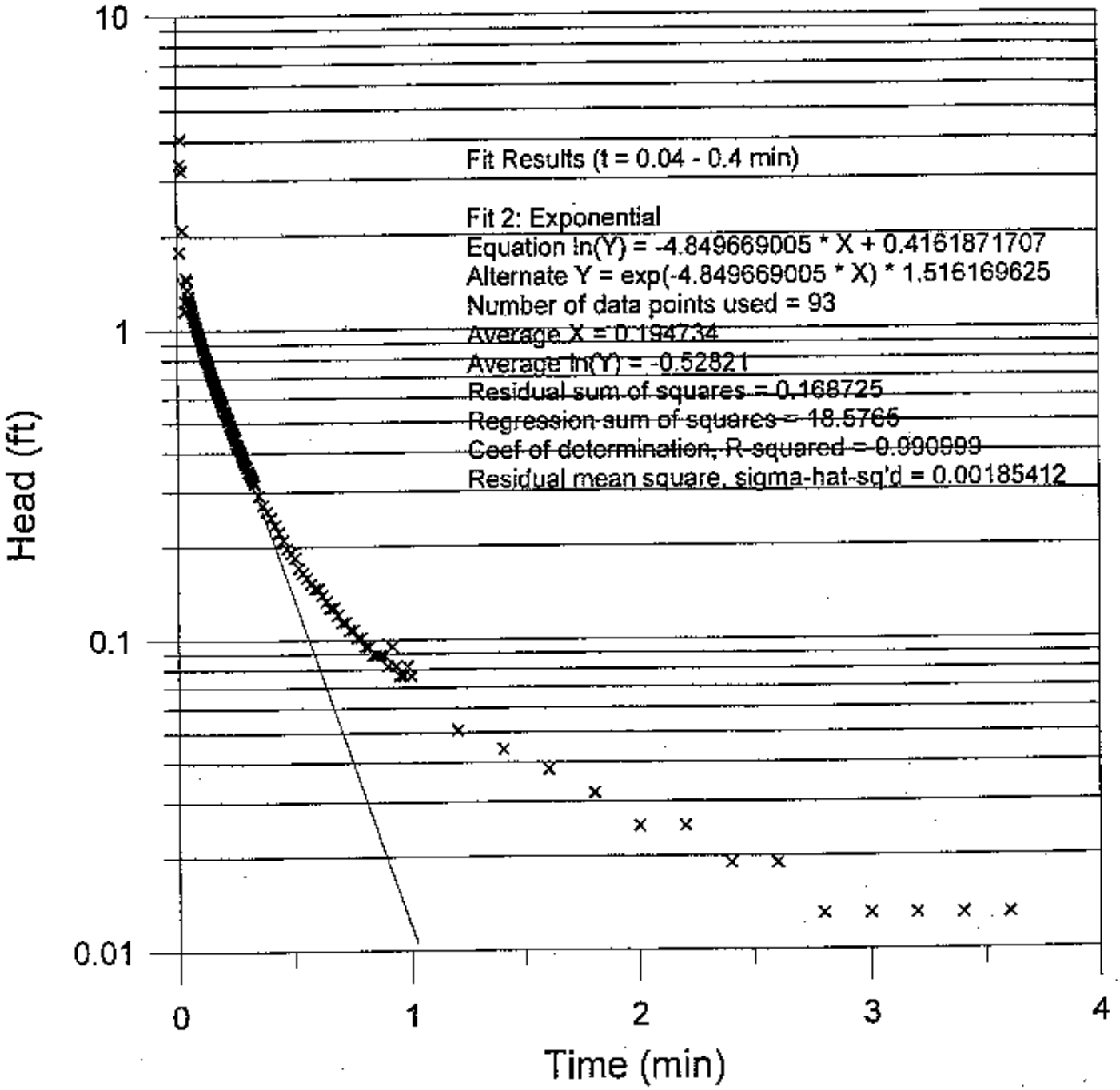
$r_s := \frac{4.026 \cdot in}{2}$ reservoir radius $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 18.97 \cdot ft$ $v_s := \pi \cdot r_s^2 \cdot l$ $v_s = 3.3 \cdot gal$ reservoir volume

$H0c := \frac{r_s^2}{r_w^2} \cdot l$ corrected displacement $H0c = 1.54 \cdot ft$ $td := 16.0 \cdot ft$ $botscreen := 15.4 \cdot ft$ $su := 1.5 \cdot ft$ $dtw := 11.75 \cdot ft$

$H := botscreen - (dtw - su)$ $H = 5.15 \cdot ft$ $D := td - (dtw - su)$ $D = 5.75 \cdot ft$ $S := .0334014834 \cdot min^{-1}$ slope $A := 2.059$ $B := 0.313$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)} \right]^{-1}$ partially penetrating case $K := \frac{r_w^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 5.8 \cdot 10^{-4} \frac{ft}{min}$ $K = 2.9 \cdot 10^{-4} \frac{cm}{sec}$

MW-1014 - Test 14 - falling



$r_c := \frac{2.245 \cdot in}{2}$ 2" Sch 6 SS (Driscoll, p. 977) $r_w := \frac{4}{2} \cdot in$ well radius $L := 5 \cdot ft$ screen length $l := 5.05 \cdot ft$ slug length

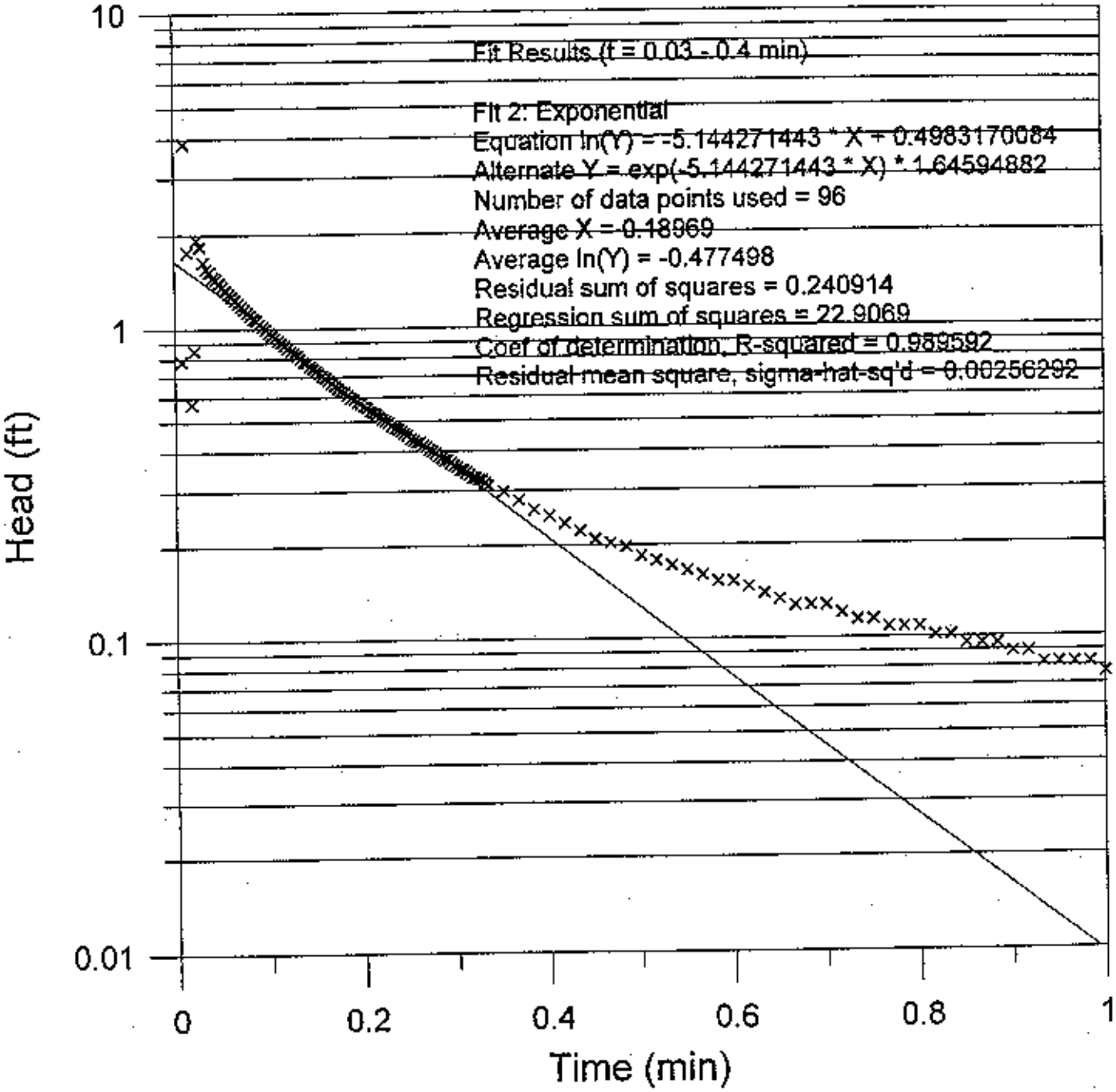
$r_s := \frac{1.25 \cdot in}{2}$ 1" PVC slug (Driscoll, p. 954) $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 1.57 \cdot ft$ $n := 0.3$ porosity $r_{cc} := \left[(1-n) \cdot r_c^2 + n \cdot r_w^2\right]^{0.5}$

$\frac{r_{cc}^2}{r_c^2} = 1.65$ $H0c := \frac{r_s^2}{r_{cc}^2} \cdot l$ corrected displacement $H0c = 0.95 \cdot ft$ $td := 437 \cdot ft$ $botscreen := 437.2 \cdot ft$ $toc := 460.37 \cdot ft$ $dtw := 8.26 \cdot ft$

$wl := toc - dtw$ $H := wl - botscreen$ $H = 14.91 \cdot ft$ $D := wl - td$ $D = 15.11 \cdot ft$ $S := 4.849669005 min^{-1}$ slope $A := 2.442$ $B := 0.397$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_c^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 1.3 \cdot 10^{-2} \frac{ft}{min}$ $K = 6.6 \cdot 10^{-3} \frac{cm}{sec}$

MW-1014 - Test 15 - rising



$r_c := \frac{2.245 \cdot in}{2}$ 2" Sch 5 SS (Driscoll, p. 977) $r_w := \frac{4}{2} \cdot in$ well radius $L := 5 \cdot ft$ screen length $l := 5.05 \cdot ft$ slug length

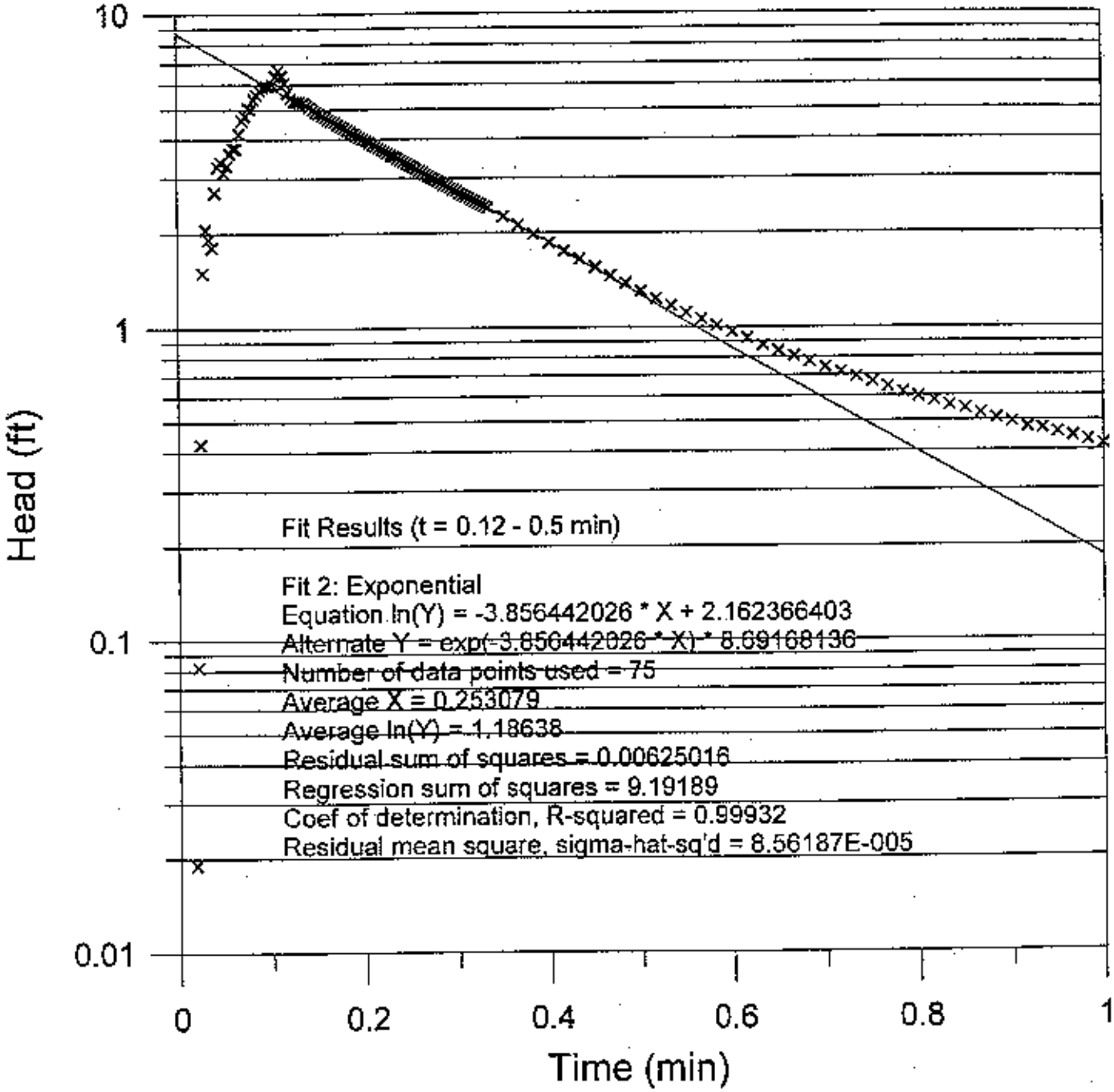
$r_s := \frac{1.25 \cdot in}{2}$ 1" PVC slug (Driscoll, p. 954) $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 1.57 \cdot ft$ $n := 0.3$ porosity $r_{cc} := \left[(1-n) \cdot r_c^2 + n \cdot r_w^2\right]^{0.5}$

$\frac{r_{cc}^2}{r_c^2} = 1.65$ $H0c := \frac{r_s^2}{r_{cc}^2} \cdot l$ corrected displacement $H0c = 0.95 \cdot ft$ $id := 437 \cdot ft$ $botscreen := 437.2 \cdot ft$ $toc := 460.37 \cdot ft$ $dtw := 8.26 \cdot ft$

$wl := toc - dtw$ $H := wl - botscreen$ $H = 14.91 \cdot ft$ $D := wl - id$ $D = 15.11 \cdot ft$ $S := 5.144271443 min^{-1}$ slope $A := 2.442$ $B := 0.397$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_c^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 1.4 \cdot 10^{-2} \frac{ft}{min}$ $K = 7 \cdot 10^{-3} \frac{cm}{sec}$

MW-1014 - Test 16 - falling h_2o



$r_c := \frac{2.245 \cdot in}{2}$ 2" Sch 5 SS (Driscoll, p. 987) $r_w := \frac{4}{2} \cdot in$ borehole radius $L := 5 \cdot ft$ screen length $l := 2 \cdot ft$ h_2o reservoir length

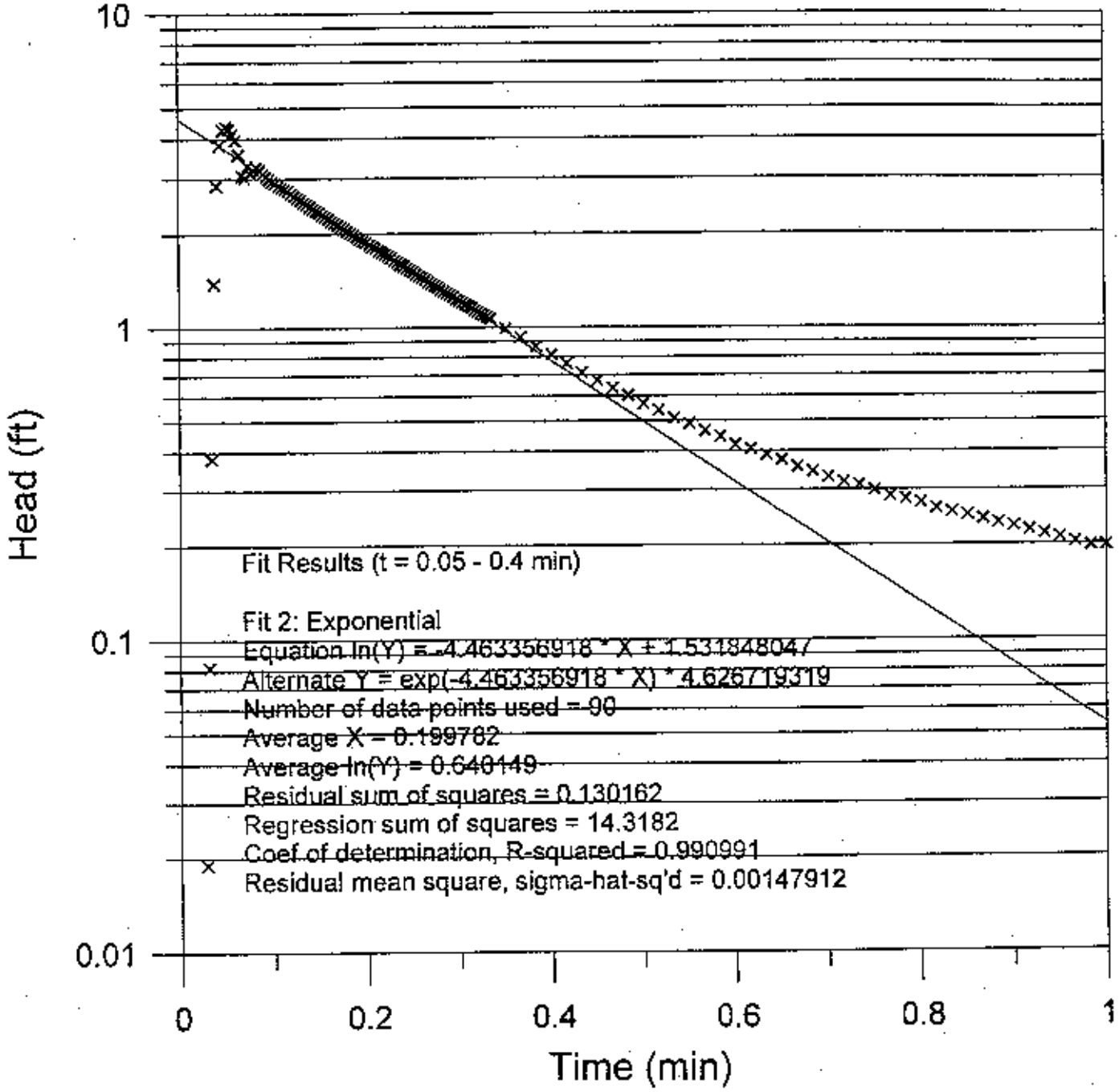
$r_s := \frac{4.026 \cdot in}{2}$ reservoir radius $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 6.43 \cdot ft$ $v_s := \pi \cdot r_s^2 \cdot l$ $v_s = 1.3 \cdot gal$ reservoir volume

$H0c := \frac{r_s^2}{r_w^2} \cdot l$ corrected displacement $H0c = 2.03 \cdot ft$ $td := 437 \cdot ft$ $botscreen := 437.2 \cdot ft$ $toc := 460.37 \cdot ft$ $dtw := 8.26 \cdot ft$

$wl := toc - dtw$ $H := wl - botscreen$ $H = 14.91 \cdot ft$ $D := wl - td$ $D = 15.11 \cdot ft$ $S := 3.856442026 min^{-1}$ slope $A := 2.442$ $B := 0.397$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)} \right]^{-1}$ partially penetrating case $K := \frac{r_c^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 1 \cdot 10^{-2} \frac{ft}{min}$ $K = 5.2 \cdot 10^{-3} \frac{cm}{sec}$

MW-1014 - Test 17 - falling h_2o



$r_c := \frac{2.245\,in}{2}$ 2" Sch 5 SS (Driscoll, p. 987) $r_w := \frac{4}{2}\cdot in$ borehole radius $L := 5\cdot ft$ screen length $l := 1.3\cdot ft$ h_2o reservoir length

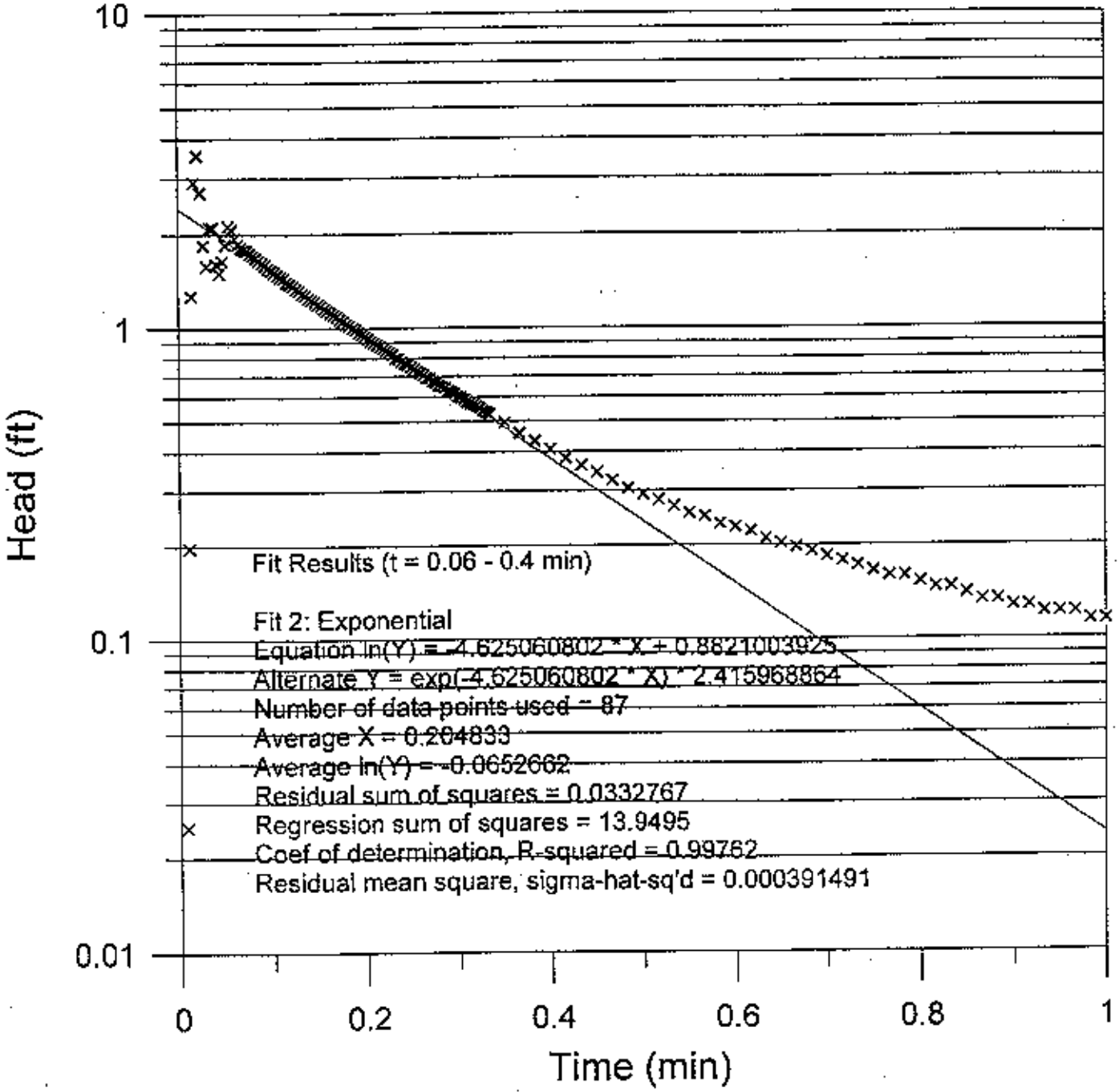
$r_s := \frac{4.026\,in}{2}$ reservoir radius $H0 := \frac{r_s^2}{r_c^2}\cdot l$ displacement $H0 = 4.18\cdot ft$ $v_s := \pi\cdot r_s^2\cdot l$ $v_s = 0.9\cdot gal$ reservoir volume

$H0c := \frac{r_s^2}{r_w^2}\cdot l$ corrected displacement $H0c = 1.32\cdot ft$ $td := 437\cdot ft$ $botscreen := 437.2\cdot ft$ $toc := 460.37\cdot ft$ $dtw := 8.26\cdot ft$

$wl := toc - dtw$ $H := wl - botscreen$ $H = 14.91\cdot ft$ $D := wl - td$ $D = 15.11\cdot ft$ $S := 4.463356918\cdot min^{-1}$ slope $A := 2.442$ $B := 0.397$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B\cdot\ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_c^2\cdot lnRerw}{2\cdot L}\cdot S$ $K = 1.2\cdot 10^{-2}\,\frac{ft}{min}$ $K = 6\cdot 10^{-3}\,\frac{cm}{sec}$

MW-1014 - Test 18 - falling h_2o



$r_c := \frac{2.245 \cdot in}{2}$ 2" Sch 5 SS (Driscoll, p. 967) $r_w := \frac{4}{2} \cdot in$ borehole radius $L := 5 \cdot ft$ screen length $l := 0.7 \cdot ft$ h_2o reservoir length

$r_s := \frac{4.026 \cdot in}{2}$ reservoir radius $H0 := \frac{r_s^2}{r_c^2} \cdot l$ displacement $H0 = 2.25 \cdot ft$ $v_s := \pi \cdot r_s^2 \cdot l$ $v_s = 0.5 \cdot gal$ reservoir volume

$H0c := \frac{r_s^2}{r_w^2} \cdot l$ corrected displacement $H0c = 0.71 \cdot ft$ $td := 437 \cdot ft$ $botscreen := 437.2 \cdot ft$ $toc := 460.37 \cdot ft$ $dtw := 8.26 \cdot ft$

$wl := toc - dtw$ $H := wl - botscreen$ $H = 14.91 \cdot ft$ $D := wl - td$ $D = 15.11 \cdot ft$ $S := 4.625060802 min^{-1}$ slope $A := 2.442$ $B := 0.397$

geometry coefficients $lnRerw := \left[\frac{1.1}{\ln\left(\frac{H}{r_w}\right)} + \frac{A + B \cdot \ln\left(\frac{D-H}{r_w}\right)}{\left(\frac{L}{r_w}\right)}\right]^{-1}$ partially penetrating case $K := \frac{r_c^2 \cdot lnRerw}{2 \cdot L} \cdot S$ $K = 1.2 \cdot 10^{-2} \frac{ft}{min}$ $K = 6.3 \cdot 10^{-3} \frac{cm}{sec}$

APPENDIX C
Packer Test Field Sheets and Calculations

QRSB-56 (19.0' - 26.0')

Given:

$L := (26.0 - 19.0)\cdot ft$ $\quad L = 7\cdot ft$ ...test interval length

$psi = 2.3067\cdot ft$

$r := \frac{2.98}{2}\cdot in$ ...radius of NQ borehole

$\nu := 1.22\cdot 10^{-5}\cdot \frac{ft^2}{sec}$ ... kinematic viscosity of water @ 60 °F

$DP1 := 0.824\cdot in$ ...id for 3/4" schedule 40 SS pipe (Driscoll, p. 976)

$DP2 := 0.622\cdot in$ ...id for 1/2" packer pipe (assume schedule 40)

$LP1 := 20\cdot ft$ ...3/4" pipe length

$LP2 := 3.5\cdot ft$ ...1/2" pipe length

$\varepsilon := 0.00014\cdot ft$ ... roughness factor for new iron pipe (Brater & King, p. 6-13)

gravity head H_G, pressure head H_P, and pumping rates Q:

$$H_G := \begin{bmatrix} 16.2 \\ 16.2 \\ 16.2 \\ 16.2 \end{bmatrix}\cdot ft \qquad H_P := \begin{bmatrix} 6 \\ 12 \\ 17 \\ 6 \end{bmatrix}\cdot psi \qquad Q := \begin{bmatrix} \frac{0.01}{10} \\ \frac{6.40}{8} \\ \frac{8.71}{8} \\ \frac{3.49}{9} \end{bmatrix}\cdot \frac{gal}{min} \qquad Q = \begin{bmatrix} 1\cdot 10^{-3} \\ 0.8 \\ 1.09 \\ 0.39 \end{bmatrix}\cdot \frac{gal}{min}$$

1) Calculate head loss through pipe (H_{LP1}) using Darcy-Weisbach equation:

Calculate velocity through packer, V1, and Reynolds Number, R1:

$A1 := \pi\cdot\frac{DP1^2}{4}$ ... area $\quad V1 := \frac{Q}{A1}$ ... velocity $\quad R1 := \frac{DP1\cdot V1}{\nu}$ $\quad$ if R1 > 2000, flow is turbulent $\quad R1 = \begin{bmatrix} 3 \\ 3\cdot 10^3 \\ 4\cdot 10^3 \\ 1\cdot 10^3 \end{bmatrix}$

Use Colebrook's equation to determine friction factor (Brater & King, p. 6-11):

$\frac{\varepsilon}{DP1} = 2.0388\cdot 10^{-3}$ ...relative roughness

$ff1 := 1$ ... initial guess at friction factor

Given

$$ff1 = \left(-2\cdot\log\left(\frac{\varepsilon}{DP1}\cdot\frac{1}{3.7} + \frac{2.51}{R1\cdot\sqrt{ff1}}\right)\right)^{-2}$$ ...ff for turbulent flow

$FRICFRAC(R1, DP1) := Find(ff1)$ $\quad i := 1 .. rows(Q)$

$ff1_i := FRICFRAC(R1_i, DP1)$ $\quad ff1_i := if\left(R1_i < 2000, \frac{64}{R1_i}, ff1_i\right)$ ...ff for laminar flow = 64/R

$$H_{LP1_i} := ff1_i\cdot\frac{LP1}{DP1}\cdot\frac{(V1_i)^2}{2\cdot g}$$ ... Darcy Weisbach equation

2) Calculate head loss through packer, H_{LP2}:

Calculate velocity through packer, V2, and Reynolds Number, R2:

$A2 := \pi\cdot\frac{DP2^2}{4}$ ... area $\quad V2 := \frac{Q}{A2}$ ...velocity $\quad R2 := \frac{DP2\cdot V2}{\nu}$ $\quad$ if R2 > 2000, flow is turbulent $\quad R2 = \begin{bmatrix} 4 \\ 3589 \\ 4884 \\ 1740 \end{bmatrix}$

Calculate friction factor, ff2:

$\frac{\varepsilon}{DP2} = 2.701\cdot10^{-3}$ ... relative roughness $\quad ff2 := 1$ ... initial guess at friction factor

Given

$$ff2 = \left(-2\cdot\log\left(\frac{\varepsilon}{DP2}\cdot\frac{1}{3.7} + \frac{2.51}{R2\cdot\sqrt{ff2}}\right)\right)^{-2}$$ ...ff for turbulent flow

$FRICFRACP(R2, DP2) := Find(ff2)$ $\quad i := 1 .. rows(Q)$ $\quad ff2_i := FRICFRACP(R2_i, DP2)$

$ff2_i := if\left(R2_i < 2000, \frac{64}{R2_i}, ff2_i\right)$ ...ff for laminar flow = 64/R $\quad H_{LP2_i} := ff2_i\cdot\frac{LP2}{DP2}\cdot\frac{(V2_i)^2}{2\cdot g}$ ... Darcy Weisbach

3) Calculate Total Head, H_T:

$$H_T := H_G + H_P - H_{LP1} - H_{LP2}$$

$$H_T = \begin{bmatrix} 30.04 \\ 43.8 \\ 55.27 \\ 30.02 \end{bmatrix}\cdot ft \quad H_G = \begin{bmatrix} 16.2 \\ 16.2 \\ 16.2 \\ 16.2 \end{bmatrix}\cdot ft \quad H_P = \begin{bmatrix} 13.84 \\ 27.68 \\ 39.21 \\ 13.84 \end{bmatrix}\cdot ft \quad H_{LP1} = \begin{bmatrix} 3.1\cdot10^{-5} \\ 0.05 \\ 0.08 \\ 0.01 \end{bmatrix}\cdot ft \quad H_{LP2} = \begin{bmatrix} 1.7\cdot10^{-5} \\ 0 \\ 0.1 \\ 6.5\cdot10^{-3} \end{bmatrix}\cdot ft$$

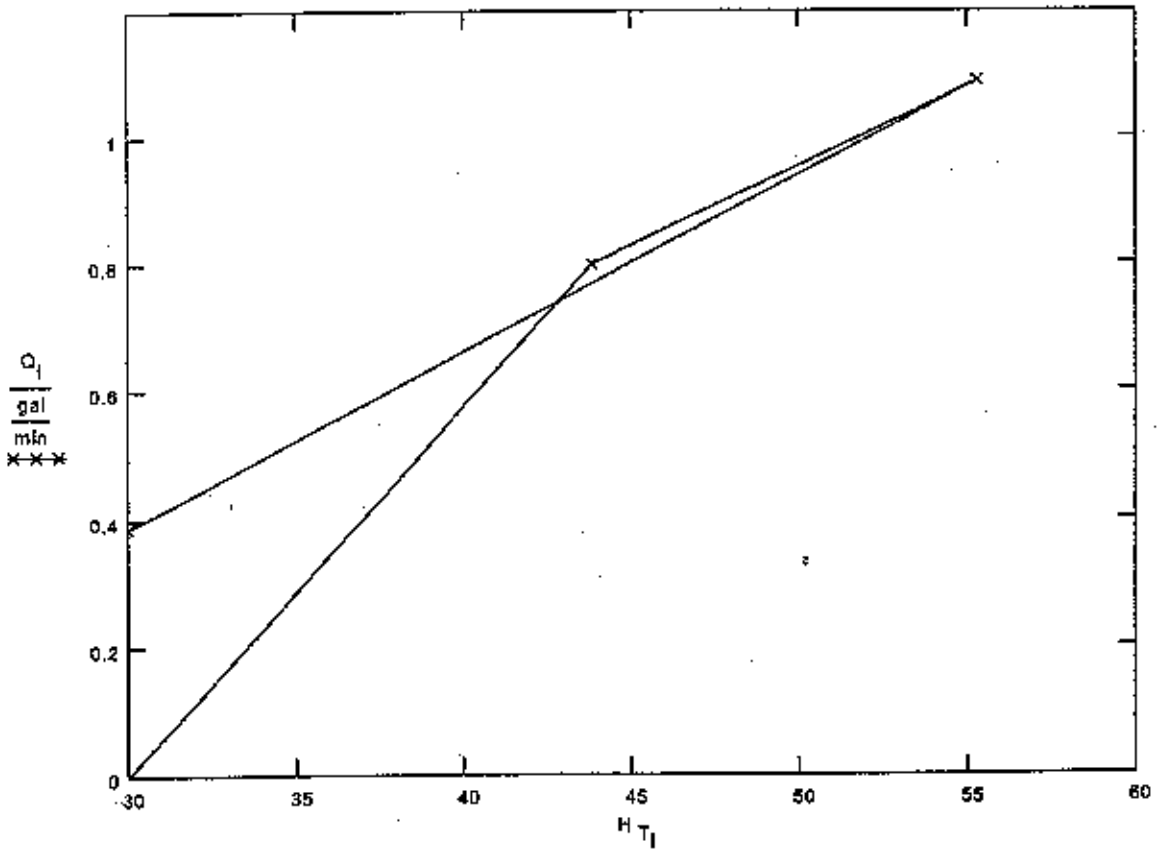
4) Calculate Hydraulic Conductivity, K (USBR 7310-89, p. 1255):

$$K_i := \frac{\overrightarrow{Q_i \cdot \ln\left(\frac{L}{r}\right)}}{2 \cdot \pi \cdot L \cdot H_{T_i}} \qquad K_i := \mathrm{if}\left(K_i > 5 \cdot 10^{-6} \cdot \frac{cm}{sec}, K_i, 0\right) \qquad K = \begin{bmatrix} 0.0 \\ 1.1 \cdot 10^{-4} \\ 1.2 \cdot 10^{-4} \\ 8.0 \cdot 10^{-5} \end{bmatrix} \cdot \frac{cm}{sec}$$

$n := \sum_i 1 \cdot (K_i > 0)$ ...number of nonzero Ks

$$Krep := \sum_i \frac{K_i \cdot (K_i > 0)}{n} \qquad Krep = 1.1 \cdot 10^{-4} \cdot \frac{cm}{sec}$$

...avg of nonzero Ks



...plot of discharge (gal/min) versus total head (ft)

QRSB-57 (10.0' - 17.8')

Given:

$L := (17.8 - 10.0)\cdot ft$ $\quad L = 7.8\cdot ft$ ...test interval length

$psi = 2.3067\cdot ft$

$r := \frac{2.98}{2}\cdot in$ ...radius of NQ borehole

$\nu := 1.22\cdot 10^{-5}\cdot\frac{ft^2}{sec}$ ... kinematic viscosity of water @ 60 °F

$DP1 := 0.824\cdot in$ ...id for 3/4" schedule 40 SS pipe (Driscoll, p. 976)

$DP2 := 0.622\cdot in$ ...id for 1/2" packer pipe (assume schedule 40)

$LP1 := 10\cdot ft$ ...3/4" pipe length

$LP2 := 3.5\cdot ft$ ...1/2" pipe length

$\varepsilon := 0.00014\cdot ft$ ... roughness factor for new iron pipe (Brater & King, p. 6-13)

gravity head H_G, pressure head H_P, and pumping rates Q:

$$H_G := \begin{bmatrix} 8.2 \\ 8.2 \\ 8.2 \\ 8.2 \end{bmatrix}\cdot ft \qquad H_P := \begin{bmatrix} 4 \\ 6 \\ 9 \\ 4 \end{bmatrix}\cdot psi \qquad Q := \begin{bmatrix} \frac{0.01}{10} \\ \frac{0.01}{10} \\ \frac{3.91}{9} \\ \frac{1.72}{8} \end{bmatrix}\cdot\frac{gal}{min} \qquad Q = \begin{bmatrix} 1\cdot 10^{-3} \\ 1\cdot 10^{-3} \\ 0.43 \\ 0.22 \end{bmatrix}\cdot\frac{gal}{min}$$

1) Calculate head loss through pipe (H_{LP1}) using Darcy-Weisbach equation:

Calculate velocity through packer, V1, and Reynolds Number, R1:

$A1 := \pi\cdot\frac{DP1^2}{4}$ ... area $\quad V1 := \frac{Q}{A1}$ ... velocity $\quad R1 := \frac{DP1\cdot V1}{\nu}$ $\quad$ if R1 > 2000, flow is turbulent $\quad R1 = \begin{bmatrix} 3 \\ 3 \\ 1\cdot 10^3 \\ 7\cdot 10^2 \end{bmatrix}$

Use Colebrook's equation to determine friction factor (Brater & King, p. 6-11):

$\frac{\varepsilon}{DP1} = 2.0388\cdot 10^{-3}$ ...relative roughness

$ff1 := 1$ ... Initial guess at friction factor

Given

$$ff1 = \left(-2\cdot\log\left(\frac{\varepsilon}{DP1}\cdot\frac{1}{3.7} + \frac{2.51}{R1\cdot\sqrt{ff1}}\right)\right)^{-2}$$ ...ff for turbulent flow

$FRICFRAC(R1, DP1) := Find(ff1)$ $\quad i := 1 .. rows(Q)$

$ff1_i := FRICFRAC(R1_i, DP1)$ $\quad ff1_i := if\left(R1_i < 2000, \frac{64}{R1_i}, ff1_i\right)$ ...ff for laminar flow = 64/R

$$H_{LP1_i} := ff1_i\cdot\frac{LP1}{DP1}\cdot\frac{(V1_i)^2}{2\cdot g}$$ ... Darcy Weisbach equation

2) Calculate head loss through packer, H_{LP2}:

Calculate velocity through packer, V2, and Reynolds Number, R2:

$A2 := \pi\cdot\frac{DP2^2}{4}$ ... area $\quad V2 := \frac{Q}{A2}$ ... velocity $\quad R2 := \frac{DP2\cdot V2}{\nu}$ $\quad$ if R2 > 2000, flow is turbulent $\quad R2 = \begin{bmatrix} 4 \\ 4 \\ 1949 \\ 964 \end{bmatrix}$

Calculate friction factor, ff2:

$\frac{\varepsilon}{DP2} = 2.701\cdot10^{-3}$ ... relative roughness $\quad ff2 := 1$ ... initial guess at friction factor

Given

$$ff2 = \left(-2\cdot\log\left(\frac{\varepsilon}{DP2}\cdot\frac{1}{3.7} + \frac{2.51}{R2\cdot\sqrt{ff2}}\right)\right)^{-2}$$ ...ff for turbulent flow

$FRICFRACP(R2, DP2) := Find(ff2)$ $\quad i := 1 .. rows(Q)$ $\quad ff2_i := FRICFRACP(R2_i, DP2)$

$ff2_i := if\left(R2_i < 2000, \frac{64}{R2_i}, ff2_i\right)$ ...ff for laminar flow = 64/R $\quad H_{LP2_i} := ff2_i\cdot\frac{LP2}{DP2}\cdot\frac{(V2_i)^2}{2\cdot g}$ ... Darcy Weisbach

3) Calculate Total Head, H_T:

$$H_T := H_G + H_P - H_{LP1} - H_{LP2}$$

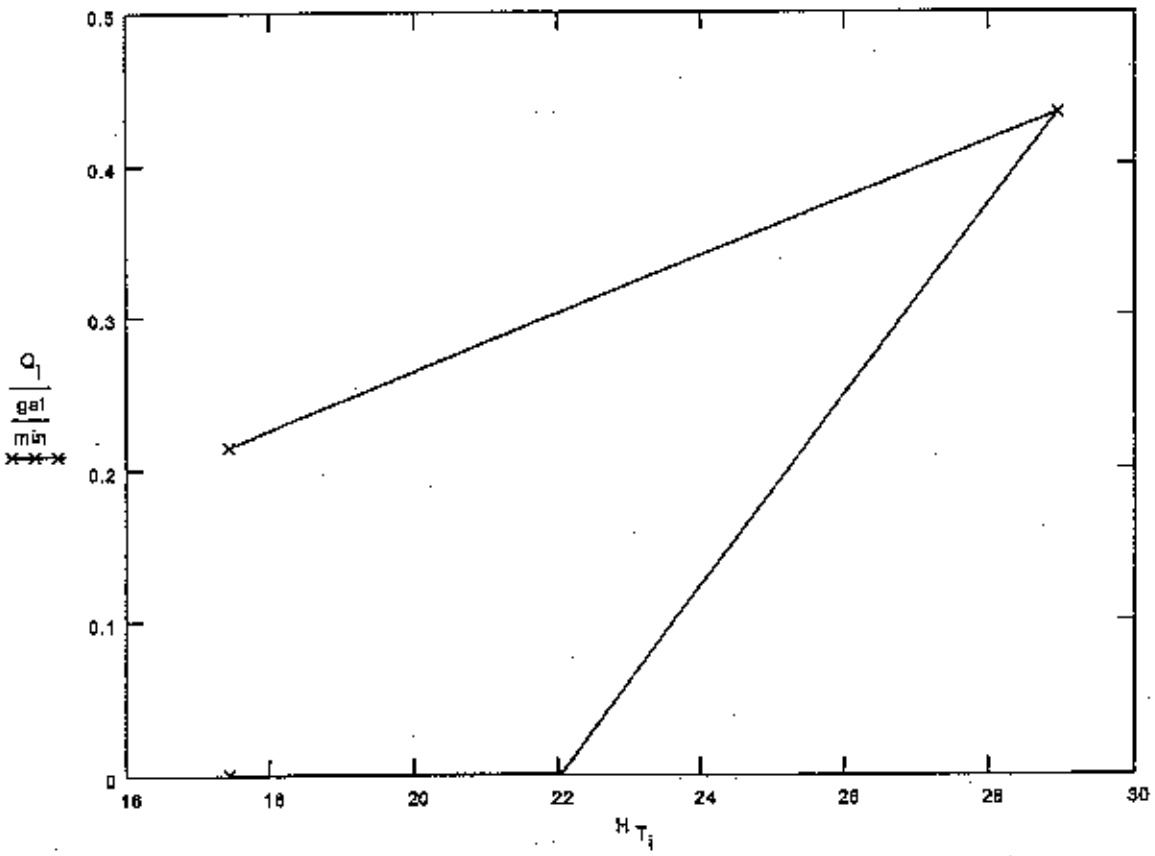
$$H_T = \begin{bmatrix} 17.43 \\ 22.04 \\ 28.95 \\ 17.42 \end{bmatrix}\cdot ft \quad H_G = \begin{bmatrix} 8.2 \\ 8.2 \\ 8.2 \\ 8.2 \end{bmatrix}\cdot ft \quad H_P = \begin{bmatrix} 9.23 \\ 13.84 \\ 20.76 \\ 9.23 \end{bmatrix}\cdot ft \quad H_{LP1} = \begin{bmatrix} 1.55\cdot10^{-5} \\ 1.55\cdot10^{-5} \\ 6.73\cdot10^{-3} \\ 3.33\cdot10^{-3} \end{bmatrix}\cdot ft \quad H_{LP2} = \begin{bmatrix} 1.7\cdot10^{-5} \\ 1.7\cdot10^{-5} \\ 7.3\cdot10^{-3} \\ 3.6\cdot10^{-3} \end{bmatrix}\cdot ft$$

4) Calculate Hydraulic Conductivity, K (USBR 7310-89, p. 1255):

$$K_i := \overrightarrow{\frac{Q_i \cdot \ln\left(\frac{L}{r}\right)}{2 \cdot \pi \cdot L \cdot H_{T_i}}} \qquad K_i := \text{if}\left(K_i > 5 \cdot 10^{-6} \cdot \frac{cm}{sec}, K_i, 0\right) \qquad K = \begin{bmatrix} 0.0 \\ 0.0 \\ 8.6 \cdot 10^{-5} \\ 7.1 \cdot 10^{-5} \end{bmatrix} \cdot \frac{cm}{sec}$$

$$n := \sum_i 1 \cdot (K_i > 0)$$ ...number of nonzero Ks

$$Krep := \sum_i \frac{K_i \cdot (K_i > 0)}{n} \qquad Krep = 7.8 \cdot 10^{-5} \cdot \frac{cm}{sec}$$ ...avg of nonzero Ks



...plot of discharge (gal/min) versus total head (ft)

MORRISON-KNUDSEN ENGINEERS, INC.

PRESSURE TEST RESULTS (FIELD)

Project:	Job Number:	Test Section:	Bore Hole:
WSSRAP QROU - Hydrogeologic Characterization	3840-394	19.0 to 250'	QRSB-51

Test Equipment Identification	BORE HOLE		Test By:
TAM International Packer Moino Centrifugal Pump Sensus Water Meter	Orientation: Vertical	Size: 3 inch	P. Putchin Date: 2/2/99

Packers	Groundwater Depth:	Gauge Height Above Ground:	Gravity Head:
On Casing (Single)/Double Hydraulic/Inflatable	6.5' Ft.	4.5' Ft.	11.0' Ft.

TEST 1 657 Inflow pressure (H_P) 6 psi × 2.31 = 13.9 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	.73	.73	.73	.73	.73	.73	.73					0 GPM CFM
Take Per Min.		0	0	0	0	0	0					CFM × 7.48 = GPM

Total Head (H_T) = Gravity Head (H_G) + Pressure Head (H_P) − Head Losses (H_L)

FT. = FT. + FT. − FT.

$$K = \frac{Q\ (gpm)}{H_T\ (ft) \times L\ (ft)} \times .011 \ln. \frac{L\ (ft)}{r\ (ft)} = \frac{\quad}{\times} \times \quad =$$

K, CM/SEC NOT QUANTIFIABLE

TEST 2 657 Inflow pressure (H_P) 12 psi × 2.31 = 27.7 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	.80	.80	.81	.81	.81	.81	.81					0 GPM CFM
Take Per Min.		0	.01	0	0	0	0					

H_T FT. = H_G FT. + H_P FT. − H_L FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\times} \times \quad =$$

K, CM/SEC NOT QUANTIFIABLE

TEST 3 Inflow pressure (H_P) 17 psi × 2.31 = 39.3 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	.81	.81	.81	.81	.81	.81	.81					0 GPM CFM
Take Per Min.		0	0	0	0	0	0					

H_T FT. = H_G FT. + H_P FT. − H_L FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\times} \times \quad =$$

K, CM/SEC NOT QUANTIFIABLE

MORRISON-KNUDSEN ENGINEERS, INC.

PRESSURE TEST RESULTS (FIELD)

Project: WSSRAP QROU Hydrogeo. Charact.	Job Number: 3840-394	Test Section: 19.0 to 25.0	Bore Hole: QRSB-51
Test Equipment Identification: Page 1	BORE HOLE Orientation: Vertical	Size: 3"	Test By: P. Patchen Date: 2/2/99
Packers: On Casing; Single/Double; Hydraulic/Inflatable	Groundwater Depth: 6.5 Ft.	Gauge Height Above Ground: 4.5 Ft.	Gravity Head: 11.0 Ft.

TEST 1

Inflow pressure (H_P) 6 psi × 2.31 = 13.9 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	.82	.82	.82	.82	.82	.82	.82					0 GPM / CFM
Take Per Min.		0	0	0	0	0						CFM × 7.48 = GPM

Total Head (H_T) = Gravity Head (H_G) + Pressure Head (H_P) − Head Losses (H_L)

FT. = FT. + FT. − FT.

$$K = \frac{Q\ (gpm)}{H_T\ (ft) \times L\ (ft)} \times .011 \ln. \frac{L\ (ft)}{r\ (ft)} = \frac{\quad}{\times} \times \quad =$$

K, CM/SEC: NOT QUANTIFIABLE

TEST 2

Inflow pressure (H_P) _____ psi × 2.31 = _____ feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.												GPM / CFM
Take Per Min.												

H_T FT. = H_G FT. + H_P FT. − H_L FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\times} \times \quad =$$

K, CM/SEC

TEST 3

Inflow pressure (H_P) _____ psi × 2.31 = _____ feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.												GPM / CFM
Take Per Min.												

H_T FT. = H_G FT. + H_P FT. − H_L FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\times} \times \quad =$$

K, CM/SEC

MORRISON-KNUDSEN ENGINEERS, INC.

PRESSURE TEST RESULTS (FIELD)

Project:	Job Number:	Test Section:	Bore Hole:
WSSRAD QROU-Hydrogeologic Characterization	3840-394	19.0 to 26.0'	QRSB-56

Test Equipment Identification	BORE HOLE		Test By:
TAM INTERNATIONAL Packer MOINO Centrifugal Pump SENSUS Water Meter	Orientation: VERTICAL	Size: 3"	P. Patchin Date: 1/28/99

Packers	Groundwater Depth:	Gauge Height Above Ground:	Gravity Head:
~~On Casing~~ Single/Double Hydraulic/Inflatable	12.7' Ft.	3.5' Ft.	16.2 Ft.

TEST 1 96 Inflow pressure (H_P) 6 psi × 2.31 = 14.7 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	19.92	.92	.92	.92	.92	.92	.92					0 GPM CFM
Take Per Min.	0	0	0	0	0	0						CFM × 7.48 = GPM

Total Head (H_T) = Gravity Head (H_G) + Pressure Head (H_P) − Head Losses (H_L)

FT. = FT. + FT. − FT.

$K = \frac{Q\ (gpm)}{H_T\ (ft) \times L\ (ft)} \times .011 \ln. \frac{L\ (ft)}{r\ (ft)} =$ ____ × ____ = K, CM/SEC NOT QUANTIFIABLE

TEST 2 962 Inflow pressure (H_P) 12 psi × 2.31 = 27.7 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	3.0	3.80	4.61	5.42	6.25	7.05	7.81	8.61	9.40			.80 GPM CFM
Take Per Min.	.80	.81	.81	.83	.80	.76	8.0	.79				

H_T 43.9 FT. = H_G 16.2 FT. + H_P 27.7 FT. − H_L ? FT.

$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} =$ $\frac{.80}{43.9 \times 7}$ × $.011 \ln \frac{7}{.25}$ = K, CM/SEC 9.53×10^{-5}

.0026 .103665

TEST 3 963 Inflow pressure (H_P) 17 psi × 2.31 = 39.3 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	4.00	5.28	6.30	7.43	9.55	9.67	40.73	1.85	2.71			1.10 GPM CFM
Take Per Min.	1.28	1.02	1.13	1.12	1.12	1.06	1.12	.86				

H_T 55.5 FT. = H_G 16.2 FT. + H_P 39.3 FT. − H_L ? FT.

$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} =$ $\frac{1.10}{55.5 \times 7}$ × $.011 \ln \frac{7}{.25}$ = K, CM/SEC 1.04×10^{-4}

.00283

MORRISON-KNUDSEN ENGINEERS, INC.

PRESSURE TEST RESULTS (FIELD)

Project:	Job Number:	Test Section:	Bore Hole:
WSSRAR QROU Hydrogeo. Char.	3840-394	19.0 to 26.0	QRSB -56

Test Equipment Identification	BORE HOLE Orientation:	BORE HOLE Size:	Test By:
Page 1	VERTICAL	3"	P. Patchen
			Date: 1/28/99

Packers	Groundwater Depth:	Gauge Height Above Ground:	Gravity Head:
On Casing Single/Double Hydraulic/Inflatable	12.7' Ft.	3.5' Ft.	16.2' Ft.

TEST 1 644 Inflow pressure (H_P) 6 psi × 2.31 = 13.9 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	.00	.35	.73	5.12	.51	.92	6.29	.70	7.07	.49		.38 ✓ GPM CFM
Take Per Min.		.35	.38	.39	.39	.41	.37	.41	.37	.32		CFM × 7.48 = GPM

Total Head (H_T) = Gravity Head (H_G) + Pressure Head (H_P) − Head Losses (H_L)

30.1 FT. = 16.2 FT. + 13.9 FT. − ? FT.

$$K = \frac{Q\ (gpm)}{H_T\ (ft) \times L\ (ft)} \times .011 \ln. \frac{L\ (ft)}{r\ (ft)} = \frac{.38}{30.1 \times 7} \times 0.011 \ln \frac{7}{.25} = K, CM/SEC\ 6.61 \times 10^{-5}$$

.00180 .03665

TEST 2 Inflow pressure (H_P) _____ psi × 2.31 = _____ feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.												GPM CFM
Take Per Min.												

H_T ____ FT. = H_G ____ FT. + H_P ____ FT. − H_L ____ FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\times} \times \quad = K, CM/SEC$$

TEST 3 Inflow pressure (H_P) _____ psi × 2.31 = _____ feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.												GPM CFM
Take Per Min.												

H_T ____ FT. = H_G ____ FT. + H_P ____ FT. − H_L ____ FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\times} \times \quad = K, CM/SEC$$

MORRISON-KNUDSEN ENGINEERS, INC.

PRESSURE TEST RESULTS (FIELD)

Project:	Job Number:	Test Section:	Bore Hole:
WSSRAP QROU - Hydrogeol Characterization	3840-394	25.0 to 35.0	QRSB - 56

Test Equipment Identification	BORE HOLE Orientation:	BORE HOLE Size:	Test By:
Tam International Packer Moino Centrifugal Pump Sensus Water Meter	vertical	3"	R. Fletcher Date: 1/29/99

Packers	Groundwater Depth:	Gauge Height Above Ground:	Gravity Head:
On Casing (Single)/Double Hydraulic/Inflatable	12.7' Ft.	2.8' Ft.	15.5' Ft.

TEST 1 9657 Inflow pressure (H_P) 10 psi × 2.31 = 23.1 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	.65	.65	.66	.67	.68	.68	.68	.69	.69			0 GPM CFM
Take Per Min.		0	.01	.01	.01	0	0	.01	.01			CFM × 7.48 = GPM

Total Head (H_T) = Gravity Head (H_G) + Pressure Head (H_P) − Head Losses (H_L)

FT. = FT. + FT. − FT.

$$K = \frac{Q\ (gpm)}{H_T\ (ft) \times L\ (ft)} \times .011 \ln. \frac{L\ (ft)}{r\ (ft)} = \frac{\quad}{\times} \times \quad =$$

K, CM/SEC: NOT QUANTIFIABLE

TEST 2 657 Inflow pressure (H_P) 15 psi × 2.31 = 34.7 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	.78	.78	.78	.78	.78	.78	.78	.78				0 GPM CFM
Take Per Min.		0	0	0	0	0	0	0				

H_T FT. = H_G FT. + H_P FT. − H_L FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\times} \times \quad =$$

K, CM/SEC: NOT QUANTIFIABLE

TEST 3 657 Inflow pressure (H_P) 20 psi × 2.31 = 46.2 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	.85	.85	.85	.85	.85	.85	.86	.86				0 GPM CFM
Take Per Min.		0	0	0	0	0	.01	0				

H_T FT. = H_G FT. + H_P FT. − H_L FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\times} \times \quad =$$

K, CM/SEC: NOT QUANTIFIABLE

MORRISON-KNUDSEN ENGINEERS, INC.

PRESSURE TEST RESULTS (FIELD)

Project:	Job Number:	Test Section:	Bore Hole:
WSSRAP QROU - Hydrogeo Charact	3840-394	25.0 to 35.0	QRSB-56

Test Equipment Identification	BORE HOLE Orientation:	BORE HOLE Size:	Test By:
1. Page 1	Vertical	3"	P. Petchen
			Date: 1/29/99

Packers: On Casing, ~~Single~~/Double, Hydraulic/Inflatable	Groundwater Depth:	Gauge Height Above Ground:	Gravity Head:
	12.7 Ft.	2.8 Ft.	15.5 Ft.

TEST 1 Inflow pressure (Hp) 10 psi × 2.31 = 23.1 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	.86	.86	.86	.86	.86	.86	.86					0 GPM
												CFM
Take Per Min.	0	0	0	0	0	0						CFM × 7.48 = GPM

Total Head (H_T) = Gravity Head (H_G) + Pressure Head (H_P) − Head Losses (H_L)

FT. = FT. + FT. − FT.

$$K = \frac{Q\ (gpm)}{H_T\ (ft) \times L\ (ft)} \times .011 \ln. \frac{L\ (ft)}{r\ (ft)} = \frac{\quad}{\times} \times \quad = \text{K, CM/SEC}$$

NOT QUANTIFIABLE

TEST 2 Inflow pressure (Hp) _____ psi × 2.31 = _____ feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.												GPM
												CFM
Take Per Min.												

H_T FT. = H_G FT. + H_P FT. − H_L FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\times} \times \quad = \text{K, CM/SEC}$$

TEST 3 Inflow pressure (Hp) _____ psi × 2.31 = _____ feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.												GPM
												CFM
Take Per Min.												

H_T FT. = H_G FT. + H_P FT. − H_L FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\times} \times \quad = \text{K, CM/SEC}$$

MORRISON-KNUDSEN ENGINEERS, INC.

PRESSURE TEST RESULTS (FIELD)

Project: WSSRAP QROU - Hydrogeologic Characterization	Job Number: 3840-394	Test Section: 10.0' to 17.8'	Bore Hole: QCB-57
Test Equipment Identification: TAM International Packer, Moyno Pump, Sensus Water Meter	BORE HOLE Orientation: Vert.	Size: 3"	Test By: P. Patchin; Date: 2/3/99
Packers: On Casing; Single/Double; Hydraulic/Inflatable	Groundwater Depth: 5.7' Ft.	Gauge Height Above Ground: 2.5' Ft.	Gravity Head: 8.2 Ft.

TEST 1 648 Inflow pressure (H_P) 4 psi × 2.31 = 9.2 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	8.00	.00	.00	.00	.00	.00	.00					0 GPM
												CFM
Take Per Min.	0	0	0	0	0	0						CFM × 7.48 = GPM

Total Head (H_T) = Gravity Head (H_G) + Pressure Head (H_P) − Head Losses (H_L)

FT. = FT. + FT. − FT.

$$K = \frac{Q\ (gpm)}{H_T\ (ft) \times L\ (ft)} \times .011 \ln. \frac{L\ (ft)}{r\ (ft)} = \frac{\quad}{\times} \times \quad = \text{K, CM/SEC}$$

NOT QUANTIFIABLE

TEST 2 8 Inflow pressure (H_P) 6 psi × 2.31 = 13.9 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	.00	.00	.00	.00	.00	.00	.00					0 GPM
												CFM
Take Per Min.	0	0	0	0	0	0						

H_T FT. = H_G FT. + H_P FT. − H_L FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\times} \times \quad = \text{K, CM/SEC}$$

NOT QUANTIFIABLE

TEST 3 49 Inflow pressure (H_P) 9 psi × 2.31 = 20.8 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	.00	.42	.85	0.30	.74	1.20	.62	2.07	.50	.91		.43 GPM
												CFM
Take Per Min.	.42	.43	.45	.44	.44	.42	.45	.43	.41			

H_T 29.0 FT. = H_G 8.2 FT. + H_P 20.8 FT. − H_L ? FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{.43}{29.0 \times 7.8} \times .011 \ln \frac{7.8}{.25} = \text{K, CM/SEC}$$

.00190 .03784

7.19×10^{-5}

MORRISON-KNUDSEN ENGINEERS, INC.

PRESSURE TEST RESULTS (FIELD)

Project: QROU Hydrogeologic Characterization	Job Number: 3840-394	Test Section: 10.0 to 17.8'	Bore Hole: QRSB-57
Test Equipment Identification: Page 1	BORE HOLE Orientation: VERTICAL	Size: 3"	Test By: P. Patchin Date: 2/3/99
Packers: On Casing; Single/Double; Hydraulic/Inflatable	Groundwater Depth: 5.7 Ft.	Gauge Height Above Ground: 2.5' Ft.	Gravity Head: 8.2 Ft.

TEST ~~1~~ 4 3 Inflow pressure (H_P) 4 psi × 2.31 = 9.2 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	.80	4.01	4.22	.43	.65	.87	5.10	.31	.52			.21 ✓ GPM / CFM
Take Per Min.	.21	.21	.21	.21	.21	.23	2.1	.21				CFM × 7.48 – GPM

Total Head (H_T) = Gravity Head (H_G) + Pressure Head (H_P) – Head Losses (H_L)

17.41 FT. = 8.2 FT. + 9.2 FT. – ? FT.

$$K = \frac{Q\ (gpm)}{H_T\ (ft) \times L\ (ft)} \times .011 \ln. \frac{L\ (ft)}{r\ (ft)} = \frac{.21}{17.4 \times 7.8} \times .011 \ln \frac{7.8}{.25} = K,\ CM/SEC\ 5.86 \times 10^{-5}$$

.00155 .03784

TEST 2 Inflow pressure (H_P) _____ psi × 2.31 = _____ feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.												GPM / CFM
Take Per Min.												

H_T ____ FT. = H_G ____ FT. + H_P ____ FT. – H_L ____ FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\quad \times \quad} \times \quad = K,\ CM/SEC$$

TEST 3 Inflow pressure (H_P) _____ psi × 2.31 = _____ feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.												GPM / CFM
Take Per Min.												

H_T ____ FT. = H_G ____ FT. + H_P ____ FT. – H_L ____ FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\quad \times \quad} \times \quad = K,\ CM/SEC$$

MORRISON-KNUDSEN ENGINEERS, INC.

PRESSURE TEST RESULTS (FIELD)

Project:	Job Number:	Test Section:	Bore Hole:
WSSRAP - QROU Hydrogeologic Characterization	3840-394	18.0 to 29.8	QRSB-57

Test Equipment Identification	BORE HOLE Orientation:	BORE HOLE Size:	Test By:
TAM International Packer, Moino Pump, Ensus Water meter	Vertical	3"	P. Patchin
			Date: 2/3/89

Packers	Groundwater Depth:	Gauge Height Above Ground:	Gravity Head:
On Casing Single/Double Hydraulic/Inflatable	5.7' Ft.	5.5' Ft.	11.2' Ft.

TEST 1 Inflow pressure (H_P) 6 psi × 2.31 = 13.9 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	.70	.73	.73	.73	.73	.73	.73					0 GPM CFM
Take Per Min.	.03	0	0	0	0	0						CFM × 7.48 = GPM

Total Head (H_T) = Gravity Head (H_G) + Pressure Head (H_P) − Head Losses (H_L)

FT. = FT. + FT. − FT.

$$K = \frac{Q\ (gpm)}{H_T\ (ft) \times L\ (ft)} \times .011 \ln. \frac{L\ (ft)}{r\ (ft)} = \frac{\quad}{\times} \times \quad = \text{K, CM/SEC}$$

NOT QUANTIFIABLE

TEST 2 65 Inflow pressure (H_P) 12 psi × 2.31 = 27.7 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	.73	.73	.75	.75	.75	.75	.75					0 GPM CFM
Take Per Min.	0	.02	0	0	0	0						

H_T FT. = H_G FT. + H_P FT. − H_L FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\times} \times \quad = \text{K, CM/SEC}$$

NOT QUANTIFIABLE

TEST 3 65 Inflow pressure (H_P) 17 psi × 2.31 = 39.3 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	.75	.75	.75	.75	.75	.75	.75					0 GPM CFM
Take Per Min.	0	0	0	0	0	0						

H_T FT. = H_G FT. + H_P FT. − H_L FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\times} \times \quad = \text{K, CM/SEC}$$

MORRISON-KNUDSEN ENGINEERS, INC.

PRESSURE TEST RESULTS (FIELD)

Project: WSSRAP - QROU	Job Number: 3840-3944	Test Section: 18.0 to 29.8'	Bore Hole: QRSB-57
Test Equipment Identification: Page 1	BORE HOLE — Orientation: VERTICAL; Size: 3"	Test By: P. Patch	Date: 2/3/99
Packers: On Casing; ~~Single~~/Double; Hydraulic/Inflatable	Groundwater Depth: 5.7' Ft.	Gauge Height Above Ground: 5.5' Ft.	Gravity Head: 11.2 Ft.

TEST ~~1~~ 4 65 Inflow pressure (H_P) 6 psi × 2.31 = 13.9 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	.75	.76	.76	.76	.76	.76	.76	.76				0 GPM / CFM
Take Per Min.		.01	0	0	0	0	0	0				CFM × 7.48 = GPM

Total Head (H_T) = Gravity Head (H_G) + Pressure Head (H_P) − Head Losses (H_L)

FT. = FT. + FT. − FT.

$$K = \frac{Q\ (gpm)}{H_T\ (ft) \times L\ (ft)} \times .011 \ln. \frac{L\ (ft)}{r\ (ft)} = \frac{\quad}{\times} \times \quad =$$

K, CM/SEC: NOT QUANTIFIABLE

TEST 2 Inflow pressure (H_P) _____ psi × 2.31 = _____ feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.												GPM / CFM
Take Per Min.												

H_T FT. = H_G FT. + H_P FT. − H_L FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\times} \times \quad =$$

K, CM/SEC

TEST 3 Inflow pressure (H_P) _____ psi × 2.31 = _____ feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.												GPM / CFM
Take Per Min.												

H_T FT. = H_G FT. + H_P FT. − H_L FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\times} \times \quad =$$

K, CM/SEC

MORRISON-KNUDSEN ENGINEERS, INC.

PRESSURE TEST RESULTS (FIELD)

Project: WSSRAP Hydrogeo. Characterization	Job Number: 3840 - 394	Test Section: 12.5 to 20.4	Bore Hole: QRSB -60
Test Equipment Identification: TAM INTERNATIONAL PACKER, MONO CENTRIFUGAL PUMP, ERSUS WATER METER	BORE HOLE Orientation: VERTICAL	Size: 3"	Test By: P. PATCHIN Date: 2/4/99
Packers: On Casing, Single/Double, Hydraulic/Inflatable	Groundwater Depth: ~3.5' Ft.	Gauge Height Above Ground: 5.0 Ft.	Gravity Head: 8.5' Ft.

TEST 1 695 Inflow pressure (H_P) 4 psi × 2.31 = 9.2 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	.00	.02	.02	.02	.03	.03	.03	.03				0 GPM / CFM
Take Per Min.		.01	.01	0	.01	0	0	0				CFM × 7.48 = GPM

Total Head (H_T) = Gravity Head (H_G) + Pressure Head (H_P) − Head Losses (H_L)

FT. = FT. + FT. − FT.

$$K = \frac{Q\ (gpm)}{H_T\ (ft) \times L\ (ft)} \times .011 \ln. \frac{L\ (ft)}{r\ (ft)} = \frac{\quad}{\times} \times \quad =$$

K, CM/SEC: NOT QUANTIFIABLE

TEST 2 695 Inflow pressure (H_P) 8 psi × 2.31 = 18.4 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	.15	.15	.16	.16	.16	.16	.16					0 GPM / CFM
Take Per Min.		0	.01	0	0	0	0					

H_T FT. = H_G FT. + H_P FT. − H_L FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\times} \times \quad =$$

K, CM/SEC: NOT QUANTIFIABLE

TEST 3 5 Inflow pressure (H_P) 13 psi × 2.31 = 30.0 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	.21	.21	.21	.21	.21	.21	.22	.22	.22			0 GPM / CFM
Take Per Min.		0	0	0	0	0	.01	.01	0			

H_T FT. = H_G FT. + H_P FT. − H_L FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\times} \times \quad =$$

K, CM/SEC

MORRISON-KNUDSEN ENGINEERS, INC.

PRESSURE TEST RESULTS (FIELD)

Project:	Job Number:	Test Section:	Bore Hole:
WSS RAP QROU Hydro Geo Char.	3840-394	12.5 to 20.4'	QRSB 60

Test Equipment Identification	BORE HOLE Orientation:	BORE HOLE Size:	Test By: / Date:
Page 1	Vert.	3"	P. Patchin / 2/4

Packers (On Casing, Single/Double, Hydraulic/Inflatable)	Groundwater Depth:	Gauge Height Above Ground:	Gravity Head:
	3.5 Ft.	5.0 Ft.	8.5' Ft.

TEST ~~1~~ 4 5 Inflow pressure (H_P) 4 psi × 2.31 = 9.2 feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.	.17	.17	.17	.17	.17	.17						0 GPM / CFM
Take Per Min.		0	0	0	0	0						CFM × 7.48 = GPM

Total Head (H_T) = Gravity Head (H_G) + Pressure Head (H_P) − Head Losses (H_L)

FT. = FT. + FT. − FT.

$$K = \frac{Q\ (gpm)}{H_T\ (ft) \times L\ (ft)} \times .011 \ln. \frac{L\ (ft)}{r\ (ft)} = \frac{\quad}{\times} \times \quad = \text{K, CM/SEC}$$

NOT QUANTIFIABLE

TEST 2 Inflow pressure (H_P) _____ psi × 2.31 = _____ feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.												GPM / CFM
Take Per Min.												

H_T FT. = H_G FT. + H_P FT. − H_L FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\times} \times \quad = \text{K, CM/SEC}$$

TEST 3 Inflow pressure (H_P) _____ psi × 2.31 = _____ feet

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
Meter Reading Gallons or Cu. Ft.												GPM / CFM
Take Per Min.												

H_T FT. = H_G FT. + H_P FT. − H_L FT.

$$K = \frac{Q}{H_T \times L} \times .011 \ln. \frac{L}{r} = \frac{\quad}{\times} \times \quad = \text{K, CM/SEC}$$

APPENDIX D
Geotechnical Testing Data Sheets

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

JOB: WSSRAP
Work Package: 513

GRADATION ANALYSIS
ASTM D422

Sample ID #: 8.6-14.0' QESB 52

Performance Log No.: NA Test Number: QC-24-03-31-01

Materials Log No. QC-26-10-31-01

Location of Test: North: NA East: NA Elev.: NA

Soil Description: Quarry Backfill Specification: NA

Balance ID No.: SC- 11 (Pass) Fail / N/A

Report %'s to the nearest whole number, except if the % passing the 75-μm (No. 200) sieve is less than 10%, it shall be reported to the nearest 0.1%.

Material Size	Required Percent Passing	Actual Percent Passing
#4		98%
#100		92%
#200	N A	76%
N A		N A
	Total Weight of Sample	35 lbs

Sieve Size	Retained Weight and Tare	Tare	Weight Retained	Initial Dry Weight	Percent Retained	Cumulative- % Retained	Cumulative- % Pass	Required
#4	9.12	0	9.12	500	1.8	2%	98%	
#100	28.56	0	28.56	500	5.7	8%	92%	
#200	81.49	0	81.49	500	16.3	24%	76%	N A
			N					
				A				

Comments: NA

Performed by: Susan L. Adams Date: 3-1-99

Reviewed by: [illegible] Date: 3-2-99

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

JOB: WSSRAP
Work Package: 513

GRADATION ANALYSIS
ASTM D422

Sample ID # 3-6-5,6,7 08S853

Performance Log No.: NA Test Number: QC-26-03-31-02

Materials Log No. QC-26-10-31-02

Location of Test: North: NA East: NA Elev.: NA

Soil Description: Quarry Backfill Specification: NA

Balance ID No.: SC-11 Pass / Fail / N/A

Report %'s to the nearest whole number, except if the % passing the 75-µm (No. 200) sieve is less than 10%, it shall be reported to the nearest 0.1%.

Material Size	Required Percent Passing	Actual Percent Passing
#4		100%
#100		100%
#200	N A	98%
N A		N A
	Total Weight of Sample	35 lbs

Sieve Size	Retained Weight and Tare	Tare	Weight Retained	Initial Dry Weight	Percent Retained	Cumulative % Retained	Cumulative % Pass	Required
#4	0	0	0	500	0	0%	100%	
#100	2.61	0	2.61	500	0.5	0%	100%	
#200	7.41	0	7.41	500	1.5	2%	98%	N A
			N					
				A				

Comments: NA

Performed by: Susan L. Adams Date: 3-2-99

Reviewed by: [illegible] Date: 3-2-99

Revision 2

Gradation Analysis Form
04-13-97

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

Job: WSSRAP
Work Package: PM5

ATTERBERG LIMIT TEST
ASTM D 4318

Sample ID # QR58 - 53 3.6' - 5.6'

Log Information

Balance ID No.: SC-10 Test No.: QC - 26 - 06 - 31 - 01

Material Log No.: QC - 26 - 10 - 31 - 02 Material meets Low Perm Requirements: (Y) / N

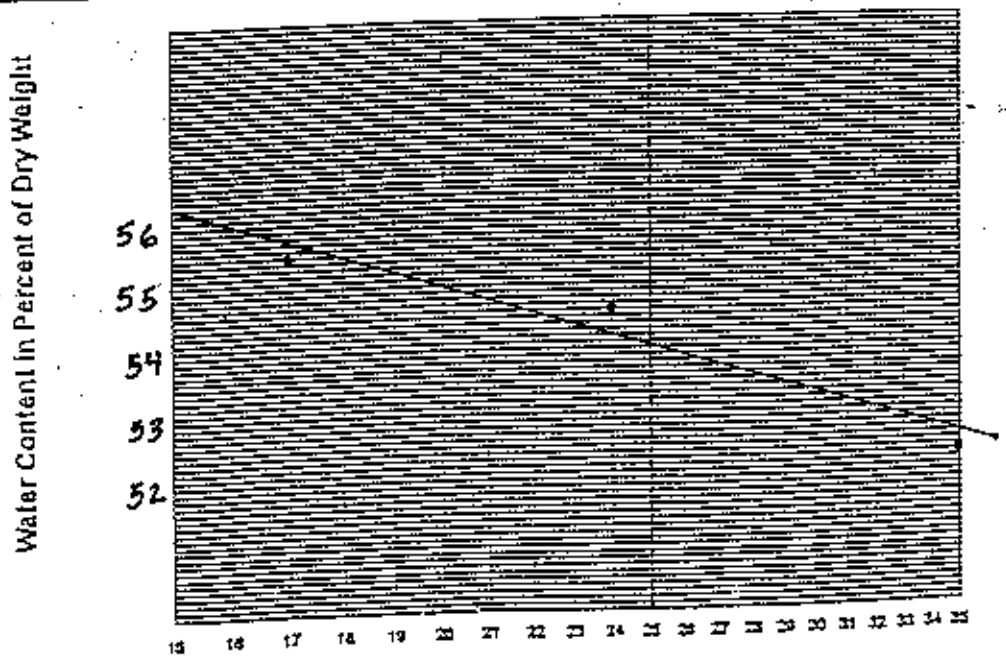
Design Specification: QUARRY BACKFILL CLASSIFICATION

Location of Test:

Northing: N/A Easting: N/A Elevation: N/A

		LIQUID LIMIT (LL)			PLASTIC LIMIT (PL)	
		LL	LL	LL	PL	PL
Number of Blows:		17	24	35		
Container Number:		7	T	4	69	22
Weight of Wet Sample and Tare:	.01	43.00 g.	44.09 g.	44.00 g.	33.98 g.	35.32 g.
Weight of Dry Sample and Tare:	.01	38.94 g.	39.56 g.	39.63 g.	32.95 g.	34.15 g.
Weight of Water:	.01	4.06 g.	4.53 g.	4.37 g.	1.03 g.	1.17 g.
Weight of Tare:	.01	31.63 g.	31.26 g.	31.28 g.	28.54 g.	29.06 g.
Weight of Dry Sample:	.01	7.31 g.	8.30 g.	8.35 g.	4.41 g.	5.09 g.
Water Content:	.1	55.5 %	54.6 %	52.3 %	23.4 %	23.0 %

FLOW CURVE



PLASTIC LIMIT (AVERAGE): 23.2 %

LIQUID LIMIT: 54.0%

PLASTICITY INDEX: (LL - PL) = PI 31 %

Comments: LL to the nearest whole number @ 25 blow line. PL and PI nearest whole number.

Performed by Ron Tyrello Date 3-2-99

Reviewed by Susan P. Edana Date 3-2-99

Revision 2

Atterberg Limit Test
04-12-97

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

JOB: WSSRAP
Work Package: 513

GRADATION ANALYSIS
ASTM D422

Sample ID #: 8.0-11.3' QR36 55

Performance Log No.: NA Test Number: QC-26-03-31-03

Materials Log No. QC-26-10-31-03

Location of Test: North: NA East: NA Elev.: NA

Soil Description: Quarry Backfill Specification: NA

Balance ID No.: SC- 11 (Pass) / Fail / N/A

Report %'s to the nearest whole number, except if the % passing the 75-µm (No. 200) sieve is less than 10%, it shall be reported to the nearest 0.1%.

Material Size	Required Percent Passing	Actual Percent Passing
#4		100%
#100		73%
#200	N A	62%
N A		N A
	Total Weight of Sample	35 lbs

Sieve Size	Retained Weight and Tare	Tare	Weight Retained	Initial Dry Weight	Percent Retained	Cumulative % Retained	Cumulative % Pass	Required
#4	0	0	0	500	0	0%	100%	
#100	136.59	0	136.59	500	27.3	27%	73%	
#200	55.57	0	55.57	500	11.1	38%	62%	N A
			N					
				A				

Comments: NA

Performed by: Susan L. Adams Date: 3-1-99

Reviewed by: [illegible] Date: 3-2-99

Revision 2

Gradation Analysis Form
04-13-97

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

Job: WSSRAP
Work Package: PM5

ATTERBERG LIMIT TEST
ASTM D 4318

Sample ID # QRSB-55 80-11.3

Log Information

Balance ID No.: SC-10

Test No.: QC-26-06-31-02

Material Log No.: QC-26-10-31-93

Material meets Low Perm Requirements: (Y) N

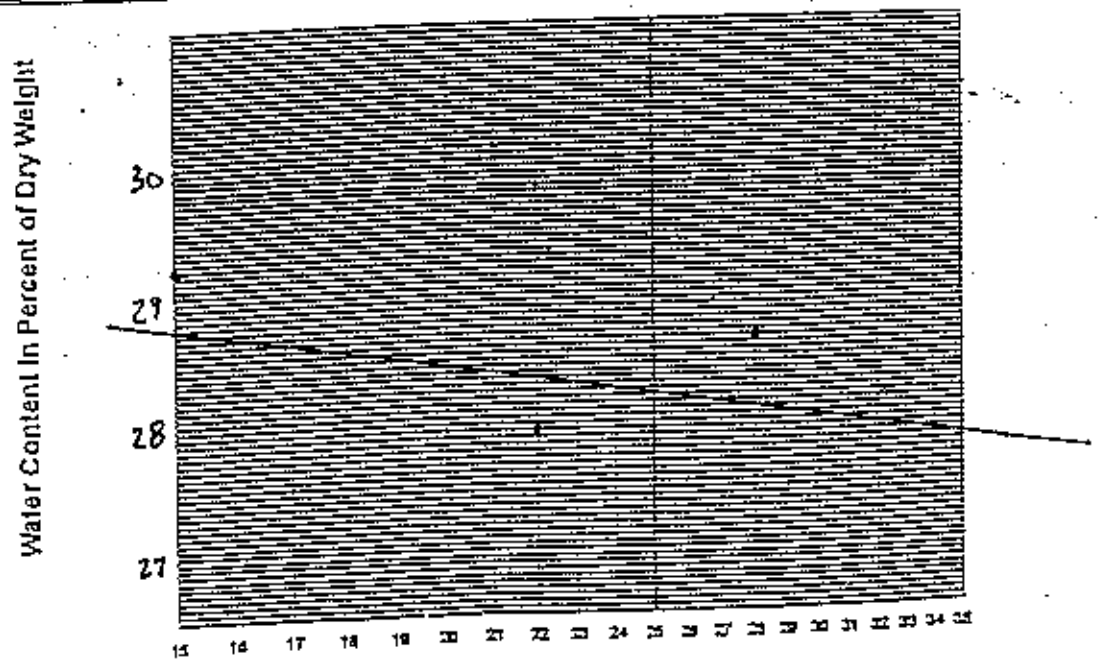
Design Specification: QUARRY BACKFILL CLASSIFICATION

Location of Test:

Northing: N/A Easting: N/A Elevation: N/A

		LIQUID LIMIT (LL)			PLASTIC LIMIT (PL)	
		LL	LL	LL	PL	PL
Number of Blows:		15	22	28		
Container Number:		55	60	21	56	48
Weight of Wet Sample and Tare:	.01	40.52 g.	38.37 g.	41.68 g.	35.12 g.	35.24 g.
Weight of Dry Sample and Tare:	.01	37.89 g.	36.00 g.	38.80 g.	34.15 g.	34.23 g.
Weight of Water:	.01	2.63 g.	2.37 g.	2.88 g.	0.97 g.	1.01 g.
Weight of Tare:	.01	28.88 g.	27.52 g.	28.72 g.	28.40 g.	28.09 g.
Weight of Dry Sample:	.01	9.01 g.	8.48 g.	10.08 g.	5.75 g.	6.14 g.
Water Content:	.1	29.2 %	27.9 %	28.6 %	16.9 %	16.4 %

FLOW CURVE



PLASTIC LIMIT (AVERAGE): 17 %

LIQUID LIMIT: 28 %

PLASTICITY INDEX: (LL - PL) = PI 11 %

Comments: LL to the nearest whole number @ 25 blow line. PL and PI nearest whole number.

Performed by Ron Trujillo Date 3-2-99

Reviewed by Susan Padamo Date 3-2-99

Revision 2

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

JOB: WSSRAP
Work Package: 513

GRADATION ANALYSIS
ASTM D422

15-4-191
Sample ID # QESB 55

Performance Log No.: NA Test Number: QC-26-03-31-04

Materials Log No. QC-26-10-31-04

Location of Test: North: NA East: NA Elev.: NA

Soil Description: Quarry Backfill Specification: NA

Balance ID No.: SC- 11 (Pass) / Fail / N/A

Report %'s to the nearest whole number, except if the % passing the 75-µm (No. 200) sieve is less than 10%, it shall be reported to the nearest 0.1%.

Material Size	Required Percent Passing	Actual Percent Passing
#4		100%
#100		100%
#200	N A	98%
N A		N A
	Total Weight of Sample	35 lbs

Sieve Size	Retained Weight and Tare	Tare	Weight Retained	Initial Dry Weight	Percent Retained	Cumulative % Retained	Cumulative % Pass	Required
#4	0	0	0	500	0	0%	100%	
#100	0	0	0	500	0	0%	100%	
#200	8.77	0	8.77	500	1.8	2%	98%	N A
			N					
				A				

Comments: NA

Performed by: Susan L Adams Date: 3-1-99

Reviewed by: [illegible] Date: 3-2-99

Revision 2

Gradation Analysis Form
04-13-97

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

Job: WSSRAP
Work Package: PM5

ATTERBERG LIMIT TEST
ASTM D 4318

Sample ID # 15.4 - 17.0 QR5B-55

Log Information

Balance ID No.: SC-10

Test No.: QC-26-06-31-03

Material Log No.: QC-26-10-31-04

Material meets Low Perm Requirements: Y (N)

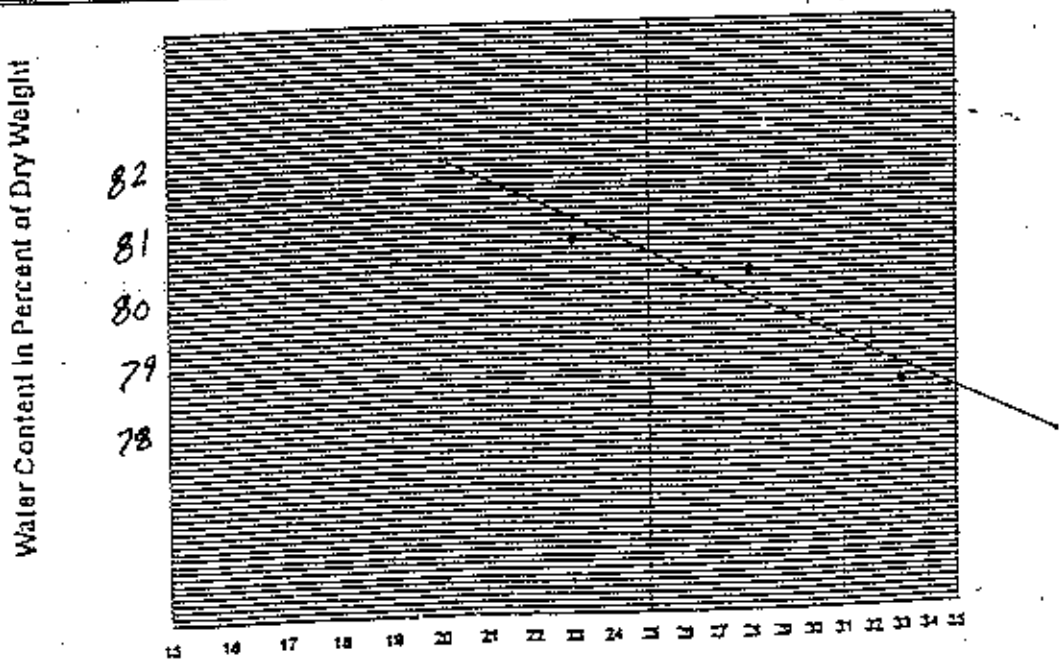
Design Specification: QUARRY BACKFILL CLASSIFICATION

Location of Test:

Northing: N/A Easting: N/A Elevation: N/A

		LIQUID LIMIT (LL)			PLASTIC LIMIT (PL)	
		LL	LL	LL	PL	PL
Number of Blows:		23	28	33	49	68
Container Number:		23	46	12	34.90 g.	34.83 g.
Weight of Wet Sample and Tare:	.01	40.16 g.	41.81 g.	42.42 g.	33.41 g.	33.39 g.
Weight of Dry Sample and Tare:	.01	35.07 g.	35.85 g.	37.55 g.	1.49 g.	1.44 g.
Weight of Water:	.01	5.09 g.	5.96 g.	4.87 g.	28.60 g.	28.83 g.
Weight of Tare:	.01	28.76 g.	28.42 g.	31.34 g.	4.81 g.	4.56 g.
Weight of Dry Sample:	.01	6.31 g.	7.43 g.	6.21 g.	31.0 %	31.6 %
Water Content:	.1	80.7 %	80.2 %	78.4 %		

FLOW CURVE



PLASTIC LIMIT (AVERAGE): 31 %

LIQUID LIMIT: 80 %

PLASTICITY INDEX: (LL - PL) = PI 49 %

Comments: LL to the nearest whole number @ 25 blow line. PL and PI nearest whole number.

Performed by [signature] Date 3-3-99

Reviewed by [signature] Date 3-3-99

Revision 2

Atterberg Limit Test

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

JOB: WSSRAP
Work Package: 513

GRADATION ANALYSIS
ASTM D422

Sample ID # 19.0-26.2' 55

Performance Log No.: NA Test Number: QC-26-03-31-05

Materials Log No. QC-26-10-31-05

Location of Test: North: NA East: NA Elev.: NA

Soil Description: Quarry Backfill Specification: NA

Balance ID No.: SC-11 Pass / Fail / N/A

Report % s to the nearest whole number, except if the % passing the 75-µm (No. 200) sieve is less than 10%, it shall be reported to the nearest 0.1%.

Material Size	Required Percent Passing	Actual Percent Passing
#4		100%
#100		50%
#200	N A	31%
N A		N A
	Total Weight of Sample	35 lbs

Sieve Size	Retained Weight and Tare	Tare	Weight Retained	Initial Dry Weight	Percent Retained	Cumulative % Retained	Cumulative % Pass	Required
#4	0	0	0	500	0	0%	100%	
#100	249.99	0	249.99	500	50.0	50%	50%	
#200	92.87	0	92.87	500	18.6	69%	31%	N A
			N					
				A				

Comments: NA

Performed by: Susan L Adams Date: 3-2-99 SLA 3-2-99

Reviewed by: [illegible] Date: 3-2-99

Revision 2

Gradation Analysis Form
04-13-87

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

Job: WSSRAP
Work Package: PMS

ATTERBERG LIMIT TEST
ASTM D 4318

Sample ID # QRSB 55 19.0 - 26.7

Log Information

Balance ID No.: SC-10

Test No.: QC-24-06-31-04

Material Log No.: QC-24-10-31-05

Material meets Low Perm Requirements: Y / (N)

Design Specification: QUARRY BACKFILL CLASSIFICATION

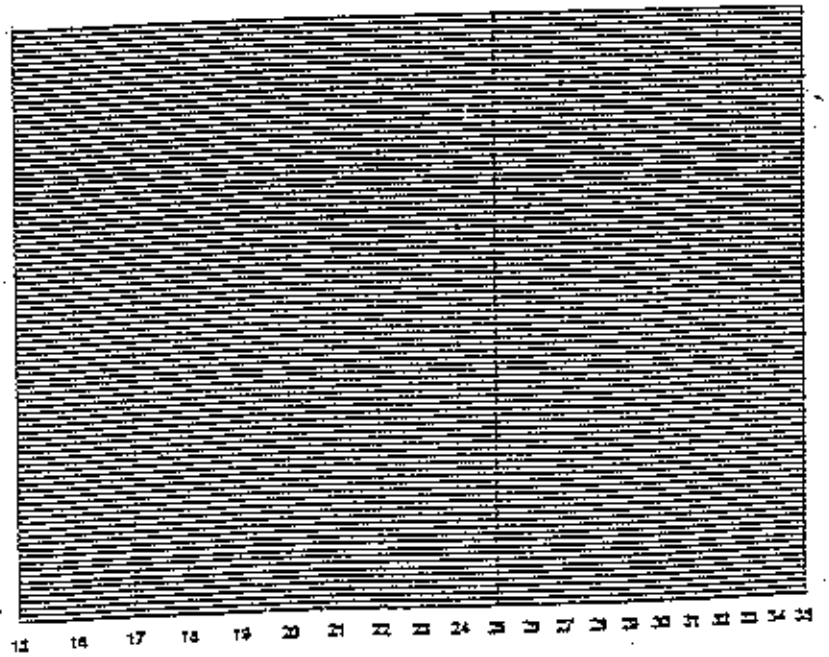
Location of Test:

Northing: N/A Easting: N/A Elevation: N/A

		LIQUID LIMIT (LL)			PLASTIC LIMIT (PL)	
		LL	LL	LL	PL	PL
Number of Blows:						
Container Number:						
Weight of Wet Sample and Tare:	.01	g.	g.	g.	g.	g.
Weight of Dry Sample and Tare:	.01	g.	g.	g.	g.	g.
Weight of Water:	.01	g.	g.	g.	g.	g.
Weight of Tare:	.01	g.	g.	g.	g.	g.
Weight of Dry Sample:	.01	g.	g.	g.	g.	g.
Water Content:	.1	%	%	%	%	%

FLOW CURVE

Water Content in Percent of Dry Weight



Number of Blows on Liquid Limit Device

PLASTIC LIMIT (AVERAGE): ____ %

LIQUID LIMIT: ____ %

PLASTICITY INDEX: (LL - PL) = PI ____ %

Comments: LL to the nearest whole number @ 25 blow line. PL and PI nearest whole number.

Non-workable material.

Performed by [signature] Date 3-3-99

Reviewed by Susan T. Adams Date 3-3-99

Revision 2

Atterberg Limit Test

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

JOB: WSSRAP
Work Package: 513

GRADATION ANALYSIS
ASTM D422

Sample ID #: 10.5-13' QC3B 56

Performance Log No.: NA Test Number: QC-26-03-31-06

Materials Log No. QC-26-10-31-06

Location of Test: North: NA East: NA Elev.: NA

Soil Description: Quarry Backfill Specification: NA

Balance ID No.: SC- 11 Pass (Fail) N/A

Report %'s to the nearest whole number, except if the % passing the 75-μm (No. 200) sieve is less than 10%, it shall be reported to the nearest 0.1%.

Material Size	Required Percent Passing	Actual Percent Passing
#4		100%
#100		
#200	N A	
		N A
N A		
	Total Weight of Sample	35 lbs

Sieve Size	Retained Weight and Tare	Tare	Weight Retained	Initial Dry Weight	Percent Retained	Cumulative % Retained	Cumulative % Pass	Required
#4	0	0	0	500	0	0%	100%	
#100	179.17	0	179.17	500	35.8	36%	64%	
#200	77.25	0	77.25	500	15.4	51%	49%	N A
			N					
				A				

Comments: NA

Performed by: Susan L. Adams Date: 3-2-99

Reviewed by: Donald J. Baker Date: 3-2-99

Revision 2

Gradation Analysis Form
04-13-87

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

JOB: WSSRAP
Work Package: 513

GRADATION ANALYSIS
ASTM D422

Sample ID #: 13D455 / 8658 56

Performance Log No.: NA Test Number: QC-24-03-31-07

Materials Log No. QC-24-10-31-07

Location of Test: North: NA East: NA Elev.: NA

Soil Description: Quarry Backfill Specification: NA

Balance ID No.: SC-11 (Pass) / Fail / N/A

Report %'s to the nearest whole number, except if the % passing the 75-µm (No. 200) sieve is less than 10%, it shall be reported to the nearest 0.1%.

Material Size	Required Percent Passing	Actual Percent Passing
#4		100%
#100		82%
#200	N A	64%
N A		N A
	Total Weight of Sample	35 lbs

Sieve Size	Retained Weight and Tare	Tare	Weight Retained	Initial Dry Weight	Percent Retained	Cumulative % Retained	Cumulative % Pass	Required
#4	0	0	0	500	0	0	100%	
#100	91.19	0	91.19	500	18.2	18%	82%	
#200	91.52	0	91.52	500	18.3	36.3%	64%	N A
			N					
				A				

Comments: NA

Performed by: Susan L Adams Date: 3-2-99

Reviewed by: Donald J Johnson Date: 3-2-99

Revision 2

Gradation Analysis Form
04-13-97

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

Job: WSSRAP
Work Package: PMS

ATTERBERG LIMIT TEST
ASTM D 4318

13.0' - 15.5'
Sample ID # QRSB 56

Log Information

Balance ID No.: SC-10 Test No.: QC-26-06-31-05

Material Log No.: QC-26-10-31-07 Material meets Low Perm Requirements: Y / (N)

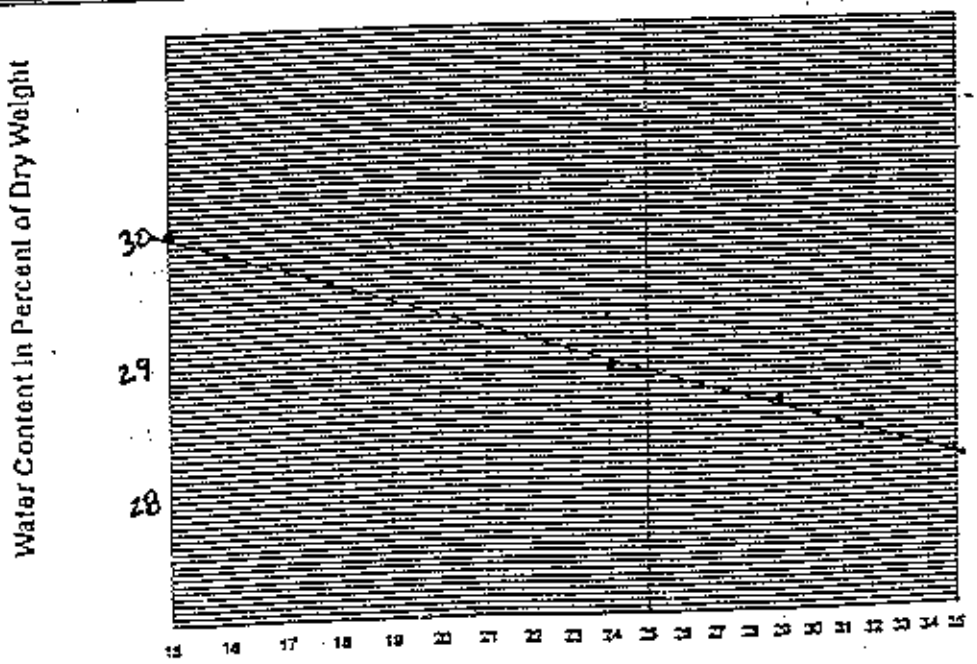
Design Specification: QUARRY BACKFILL CLASSIFICATION

Location of Test:

Northing: N/A Easting: N/A Elevation: N/A

		LIQUID LIMIT (LL)			PLASTIC LIMIT (PL)	
		LL	LL	LL	PL	PL
Number of Blows:		15	24	29	32	44
Container Number:		72	80	51	36.06 g.	36.37 g.
Weight of Wet Sample and Tare:	.01	41.63 g.	43.24 g.	40.75 g.	34.86 g.	34.25 g.
Weight of Dry Sample and Tare:	.01	38.57 g.	39.96 g.	38.02 g.	1.20 g.	1.17 g.
Weight of Water:	.01	3.06 g.	3.28 g.	2.73 g.	29.09 g.	28.70 g.
Weight of Tare:	.01	28.37 g.	28.61 g.	28.47 g.	5.77 g.	5.55 g.
Weight of Dry Sample:	.01	10.2 g.	11.35 g.	9.56 g.	20.8 %	20.2 %
Water Content:	.1	30 %	28.9 %	28.6 %		

FLOW CURVE



PLASTIC LIMIT (AVERAGE): 20 %

LIQUID LIMIT: 29 %

PLASTICITY INDEX: (LL - PL) = PI 9 %

Comments: LL to the nearest whole number @ 25 blow line. PL and PI nearest whole number.

Performed by [signature] Date 3-2-99

Reviewed by Susan L. Adams Date 3-2-99

Revision 2

Atterberg Limit Test

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

JOB: WSSRAP
Work Package: 513

GRADATION ANALYSIS
ASTM D422

Sample ID # QESB 57 5.8.3'

Performance Log No.: NA Test Number: QC-26-03-31-08

Materials Log No. QC-26-10-31-08

Location of Test: North: NA East: NA Elev.: NA

Soil Description: Quarry Backfill Specification: NA

Balance ID No.: SC-11 (Pass) / Fail / N/A

Report %'s to the nearest whole number, except if the % passing the 75-µm (No. 200) sieve is less than 10%, it shall be reported to the nearest 0.1%.

Material Size	Required Percent Passing	Actual Percent Passing
#4		100%
#100		89%
#200	N A	79%
N A		N A
	Total Weight of Sample	35 lbs

Sieve Size	Retained Weight and Tare	Tare	Weight Retained	Initial Dry Weight	Percent Retained	Cumulative % Retained	Cumulative % Pass	Required
#4	0	0	0	500	0	0%	100%	
#100	54.13	0	54.13	500	10.8	11%	89%	
#200	61.94	0	61.94	500	~~8.1~~ 12.4 ~~2-2-99~~	~~23.1~~ 23.5% ~~2-2-99~~	~~77.9~~ 77% ~~2-2-99~~	N A
			N					
				A				

Comments: NA

Performed by: Sean L. Adamo Date: 3-2-99

Reviewed by: [illegible] Date: 3-2-99

Revision 2

Gradation Analysis Form
04-13-97

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

Job: WSSRAP
Work Package: PMS

ATTERBERG LIMIT TEST
ASTM D 4318

5.0 - 8.3
Sample ID # QRSB-57

Log Information

Balance ID No.: SC-10

Test No.: QC-26-06-31-06

Material Log No.: QC-26-10-31-08

Material meets Low Perm Requirements: (Y) / N

Design Specification: QUARRY BACKFILL CLASSIFICATION

Location of Test:

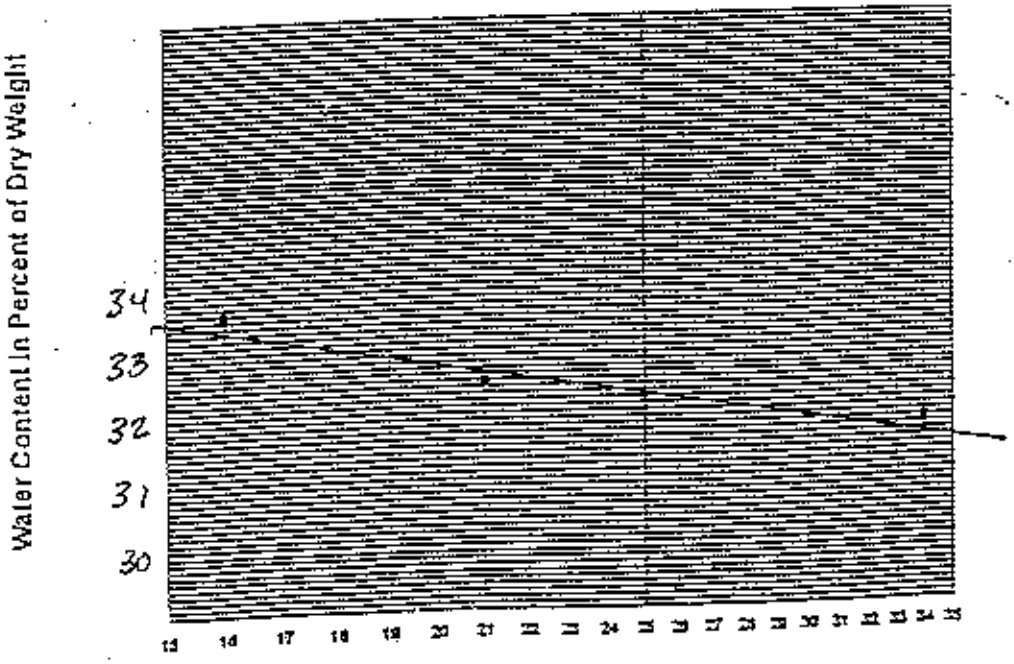
Northing: N/A

Easting: N/A

Elevation: N/A

		LIQUID LIMIT (LL)			PLASTIC LIMIT (PL)	
		LL	LL	LL	PL	PL
Number of Blows:		16	21	34		
Container Number:		7	T	22	35.29	37.97
Weight of Wet Sample and Tare:	.01	46.83 g.	45.24 g.	43.86 g.	69 g.	4 g.
Weight of Dry Sample and Tare:	.01	43.01 g.	41.81 g.	40.29 g.	34.22 g.	36.93 g.
Weight of Water:	.01	3.82 g.	3.43 g.	3.57 g.	1.07 g.	1.04 g.
Weight of Tare:	.01	31.63 g.	31.26 g.	29.05 g.	28.55 g.	31.32 g.
Weight of Dry Sample:	.01	11.38 g.	10.55 g.	11.24 g.	5.67 g.	5.61 g.
Water Content:	.1	33.6 %	32.5 %	31.8 %	18.9 %	18.5 %

FLOW CURVE



PLASTIC LIMIT (AVERAGE): 19 %

LIQUID LIMIT: 32 %

PLASTICITY INDEX: (LL - PL) = PI 13 %

Comments: LL to the nearest whole number @ 25 blow line. PL and PI nearest whole number.

Performed by [signature] Date 3-3-99

Reviewed by Susan T. Adams Date 3-3-99

Revision 2

Atterberg Limit Test

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

JOB: WSSRAP
Work Package: 513

GRADATION ANALYSIS
ASTM D422

Sample ID #: 95-1321 QCSB 58

Performance Log No.: NA Test Number: QC-26-03-31-09

Materials Log No. QC-26-10-31-09

Location of Test: North: NA East: NA Elev.: NA

Soil Description: Quarry Backfill Specification: NA

Balance ID No.: SC- 11 Pass / Fail / N/A

Report %'s to the nearest whole number, except if the % passing the 75-µm (No. 200) sieve is less than 10%, it shall be reported to the nearest 0.1%.

Material Size	Required Percent Passing	Actual Percent Passing
#4		100%
#100		99%
#200	N A	96%
N A		N A
	Total Weight of Sample	35 lbs

Sieve Size	Retained Weight and Tare	Tare	Weight Retained	Initial Dry Weight	Percent Retained	Cumulative % Retained	Cumulative % Pass	Required
#4	0	0	0	500	0	0%	100%	
#100	5.74	0	5.74	500	1.1	1%	99%	
#200	15.34	0	15.34	500	3.1	4%	96%	N A
			N					
				A				

Comments: NA

Performed by: Susan L. Adams Date: 3-3-99

Reviewed by: [illegible] Date: 3-3-99

Revision 2

Gradation Analysis Form
04-13-97

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

Job: WSSRAP
Work Package: PMS

ATTERBERG LIMIT TEST
ASTM D 4318

Sample ID # QESB-58 9.5 - 13.2'

Log Information

Balance ID No.: SC-10

Test No.: QC-26-06-31-07

Material Log No.: QC-26-10-31-09

Material meets Low Perm Requirements: (Y) N

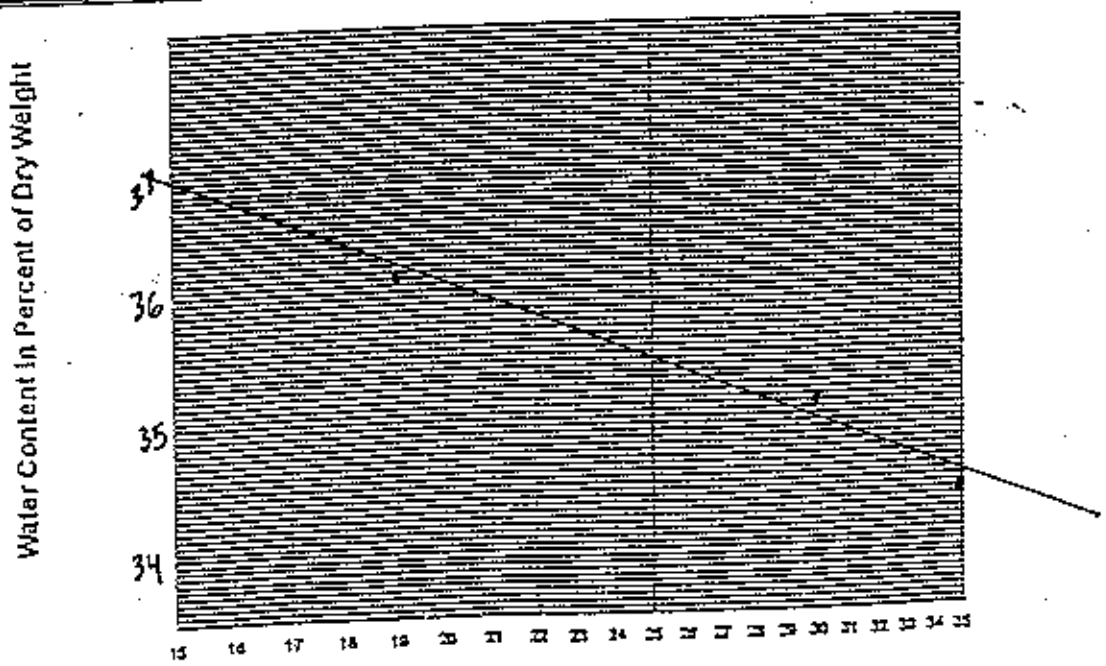
Design Specification: QUARRY BACKFILL CLASSIFICATION

Location of Test:

Northing: N/A Easting: N/A Elevation: N/A

		LIQUID LIMIT (LL)			PLASTIC LIMIT (PL)	
		LL	LL	LL	PL	PL
Number of Blows:		19	30	35		
Container Number:		63	26'	68	49	5'
Weight of Wet Sample and Tare:	.01	41.02 g.	38.56 g.	41.35 g.	35.52 g.	38.70 g.
Weight of Dry Sample and Tare:	.01	37.45 g.	35.72 g.	38.06 g.	34.23 g.	37.32 g.
Weight of Water:	.01	3.57 g.	2.84 g.	3.19 g.	1.29 g.	1.38 g.
Weight of Tare:	.01	27.55 g.	27.63 g.	28.79 g.	28.61 g.	31.36 g.
Weight of Dry Sample:	.01	9.90 g.	8.09 g.	9.27 g.	5.62 g.	5.96 g.
Water Content:	.1	36.1 %	35.1 %	34.4 %	23.0 %	23.2 %

FLOW CURVE



PLASTIC LIMIT (AVERAGE): 23.0 %

LIQUID LIMIT: 35 %

PLASTICITY INDEX: (LL - PL) = PI 12 %

Comments: LL to the nearest whole number @ 25 blow line. PL and PI nearest whole number.

Performed by Ron Trujillo Date 3-2-99

Reviewed by Susan L Adams Date 3-2-99

Revision 2

Atterberg Limit Test

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

Job: WSSRAP
Work Package: 513

GRADATION ANALYSIS
ASTM D422

Sample ID #: 12-22-1

Performance Log No.: NA Test Number: QC-26-03-31-10

Materials Log No. QC-26-10-31-10

Location of Test: North: NA East: NA Elev.: NA

Soil Description: Quarry Backfill Specification: NA

Balance ID No.: SC-11 Pass / Fail / N/A

Report % s to the nearest whole number, except if the % passing the 75-µm (No. 200) sieve is less than 10%, it shall be reported to the nearest 0.1%.

Material Size	Required Percent Passing	Actual Percent Passing
#4		100%
#100		15%
#200	N A	13%
N A		N A
	Total Weight of Sample	35 lbs

Sieve Size	Retained Weight and Tare	Tare	Weight Retained	Initial Dry Weight	Percent Retained	Cumulative % Retained	Cumulative % Pass	Required
#4	0	0	0	500	0	0%	100%	
#100	426.86	0	426.86	500	85.4	85%	15%	
#200	8.22	0	8.22	500	1.6	87%	13%	N A
			N					
				A				

Comments: NA

Performed by: Susan L. Adams Date: 3-1-99

Reviewed by: [illegible] Date: 3-2-99

Revision 2

Gradation Analysis Form
04-12-97

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

JOB: WSSRAP
Work Package: 513

GRADATION ANALYSIS
ASTM D422

Sample ID # 23.6-26'

Performance Log No.: NA Test Number: QC-26-03-31-11

Materials Log No. QC-26-10-31-11

Location of Test: North: NA East: NA Elev.: NA

Soil Description: Quarry Backfill Specification: NA

Balance ID No.: SC- 11 Pass / Fail / N/A

Report %'s to the nearest whole number, except if the % passing the 75-μm (No. 200) sieve is less than 10%, it shall be reported to the nearest 0.1%.

Material Size	Required Percent Passing	Actual Percent Passing
#4		100%
#100		31%
#200	N A	6%
N A		N A
	Total Weight of Sample	35 lbs

Sieve Size	Retained Weight and Tare	Tare	Weight Retained	Initial Dry Weight	Percent Retained	Cumulative % Retained	Cumulative % Pass	Required
#4	0	0	0	500	0	0%	100%	
#100	347.22	0	347.22	500	69.4	69%	31%	
#200	123.87	0	123.87	500	24.8	94%	6%	N A
			N					
				A				

Comments: NA

Performed by: Susan L. Adams Date: 3-1-99

Reviewed by: [illegible signature] Date: 3-2-99

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

JOB: WSSRAP
Work Package: 513

GRADATION ANALYSIS
ASTM D422

Sample ID # QESB 59 10.2-13.3'

Performance Log No.: NA Test Number: QC-24-03-31-12

Materials Log No. QC-24-10-31-12

Location of Test: North: NA East: NA Elev.: NA

Soil Description: Quarry Backfill Specification: NA

Balance ID No.: SC-11 (Pass) / Fail / N/A

Report %'s to the nearest whole number, except if the % passing the 75-µm (No. 200) sieve is less than 10%, it shall be reported to the nearest 0.1%.

Material Size	Required Percent Passing	Actual Percent Passing
#4		100%
#100		90%
#200	N A	76%
N A		N A
	Total Weight of Sample	35 lbs

Sieve Size	Retained Weight and Tare	Tare	Weight Retained	Initial Dry Weight	Percent Retained	Cumulative % Retained	Cumulative % Pass	Required
#4	0	0	0	500	0	0%	100%	
#100	47.89	0	47.89	500	9.6	10%	90%	
#200	74.29	0	74.29	500	14.9	24%	76%	N A
			N					
				A				

Comments:

Performed by: [signature] Date: 3-2-99

Reviewed by: [signature] Date: 3-2-99

Revision 2

Gradation Analysis Form
04-10-97

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

Job: WSSRAP
Work Package: PM5

ATTERBERG LIMIT TEST
ASTM D 4318

10.3' - 13.3'
Sample ID # QBSB - 59

Log Information

Balance ID No.: SC-10

Test No.: QC - 26 - 06 - 31-08

Material Log No.: QC - 26 - 10 - 31 - 12

Material meets Low Perm Requirements: (Y) / N

Design Specification: QUARRY BACKFILL CLASSIFICATION

Location of Test:

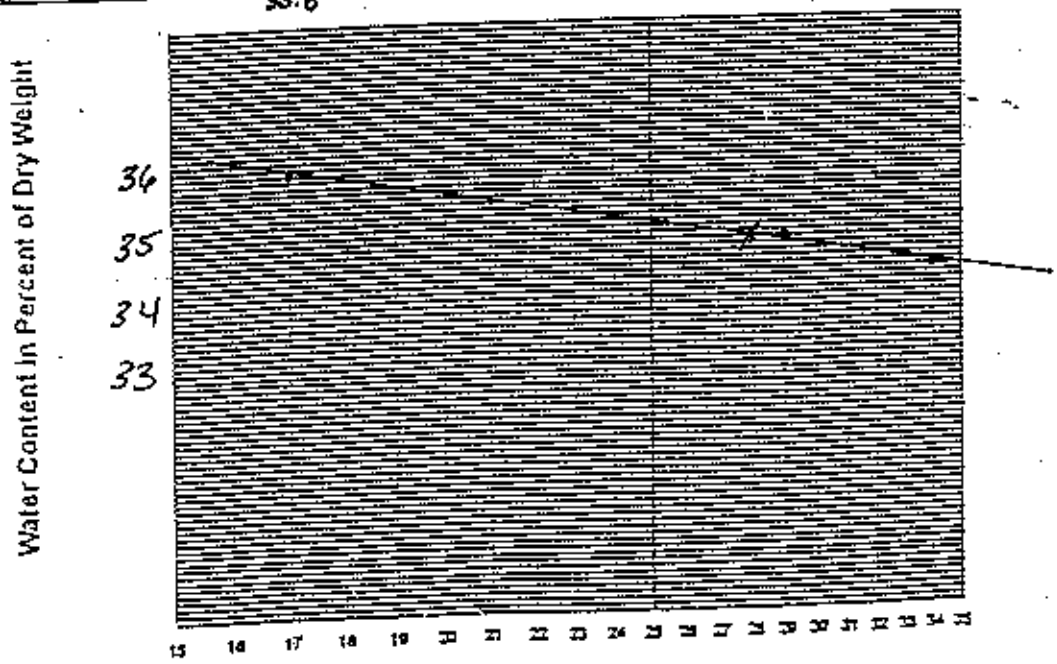
Northing: N/A

Easting: N/A

Elevation: N/A

		LIQUID LIMIT (LL)			PLASTIC LIMIT (PL)	
		LL	LL	LL	PL	PL
Number of Blows:		17	29	34		
Container Number:		32	44	51	80	72
Weight of Wet Sample and Tare:	.01	42.48 g.	41.44 g.	42.52 g.	35.83 g.	34.87 g.
Weight of Dry Sample and Tare:	.01	38.95 g.	38.16 g.	38.96 g.	34.51 g.	33.68 g.
Weight of Water:	.01	3.53 g.	3.28 g.	3.56 g.	1.32 g.	1.19 g.
Weight of Tare:	.01	29.08 g.	28.70 g.	28.55 g.	28.63 g.	28.42 g.
Weight of Dry Sample:	.01	9.87 g.	9.46 g.	10.41 g.	5.88 g.	5.24 g.
Water Content:	.1	33.7 %	34.7 %	34.2 %	22.4 %	22.6 %

FLOW CURVE



PLASTIC LIMIT (AVERAGE): 22 %

LIQUID LIMIT: 35 %

PLASTICITY INDEX: (LL - PL) = PI 13 %

Comments: LL to the nearest whole number @ 25 blow line. PL and PI nearest whole number.

Performed by Susan L Adams — Date 3-3-99

Reviewed by Don Trujillo — Date 3-3-99

Revision 2

Atterberg Limit Test

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

JOB: WSSRAP
Work Package: 513

GRADATION ANALYSIS
ASTM D422

Sample ID # 18.3-20.3 0238 57

Performance Log No.: NA Test Number: QC-24-03-31-13

Materials Log No. QC-24-10-31-13

Location of Test: North: NA East: NA Elev.: NA

Soil Description: Quarry Backfill Specification: NA

Balance ID No.: SC-11 Pass (Fail) N/A

Report %'s to the nearest whole number, except if the % passing the 75-µm (No. 200) sieve is less than 10%, it shall be reported to the nearest 0.1%.

Material Size	Required Percent Passing	Actual Percent Passing
#4		100%
#100		27%
#200	N A	17%
N A		N A
	Total Weight of Sample	35 lbs

Sieve Size	Retained Weight and Tare	Tare	Weight Retained	Initial Dry Weight	Percent Retained	Cumulative % Retained	Cumulative % Pass	Required
#4	1.85	0	1.85	500	0.4	0%	100%	
#100	364.35	0	364.35	500	72.9	73%	27%	
#200	50.27	0	50.27	500	10.1	83%	17%	N A
			N					
				A				

Comments: NA

Performed by: Susan L Adams Date: 3-2-99

Reviewed by: Daniel J Sehe Date: 3-2-99

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

Job: WSSRAP
Work Package: 513

GRADATION ANALYSIS
ASTM D422

Sample ID # 32-5.7' 0238.00

Performance Log No.: NA Test Number: QC-26-03-31-14

Materials Log No. QC-26-10-31-14

Location of Test: North: NA East: NA Elev.: NA

Soil Description: Quarry Backfill Specification: NA

Balance ID No.: SC-11 Pass / Fail / N/A

Report %'s to the nearest whole number, except if the % passing the 75-µm (No. 200) sieve is less than 10%, it shall be reported to the nearest 0.1%.

Material Size	Required Percent Passing	Actual Percent Passing
#4		85%
#100		77%
#200	N A	74%
N A		N A
	Total Weight of Sample	35 lbs

Sieve Size	Retained Weight and Tare	Tare	Weight Retained	Initial Dry Weight	Percent Retained	Cumulative % Retained	Cumulative % Pass	Required
#4	70.58	0	70.58	5092102.3	3.4	15%	85%	
#100	173.17	0	173.17	5002102.3	8.2	23%	77%	
#200	65.22	0	65.22	5002102.3	3.1	26%	74%	N A
			N					
				A				

Comments: see attached sheet for 1" sieve.

Performed by: Susan P. Adams Date: 3-3-99

Reviewed by: Don Tyllo Date: 3-3-99

SIEVE ANALYSIS

ASTM D-422

Test No. : QRSB-60 3.2'-5.7'

Seive Size	Actual Weight	Adjustment Multiplier	Adjusted Weight	Initial Dry Weight (g)	Adjusted % Retained	Cumulative Adjusted % Retained	Cumulative Adjusted % Pass
1"	241.00	1.00	241.00	2102.30	11.5%	11.5%	88.5%
# 4	70.58	1.00	70.58	2102.30	3.4%	14.8%	85.2%
#100	173.17	1.00	173.17	2102.30	8.2%	23.1%	76.9%
#200	65.22	1.00	65.22	2102.30	3.1%	26.2%	73.8%

Performed By : Susan L. Adams Date : 3-3-99

Reviewed By : Don Tryllo Date : 3-3-99

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

Job: WSSRAP
Work Package: PMS

ATTERBERG LIMIT TEST
ASTM D 4318

Sample ID # GRJR - 60 3.2 - 5.7

Log Information

Balance ID No.: SC-10 Test No.: QC - 26 - 06-31-09

Material Log No.: QC-26 -10-31-14 Material meets Low Perm Requirements: (Y) / N

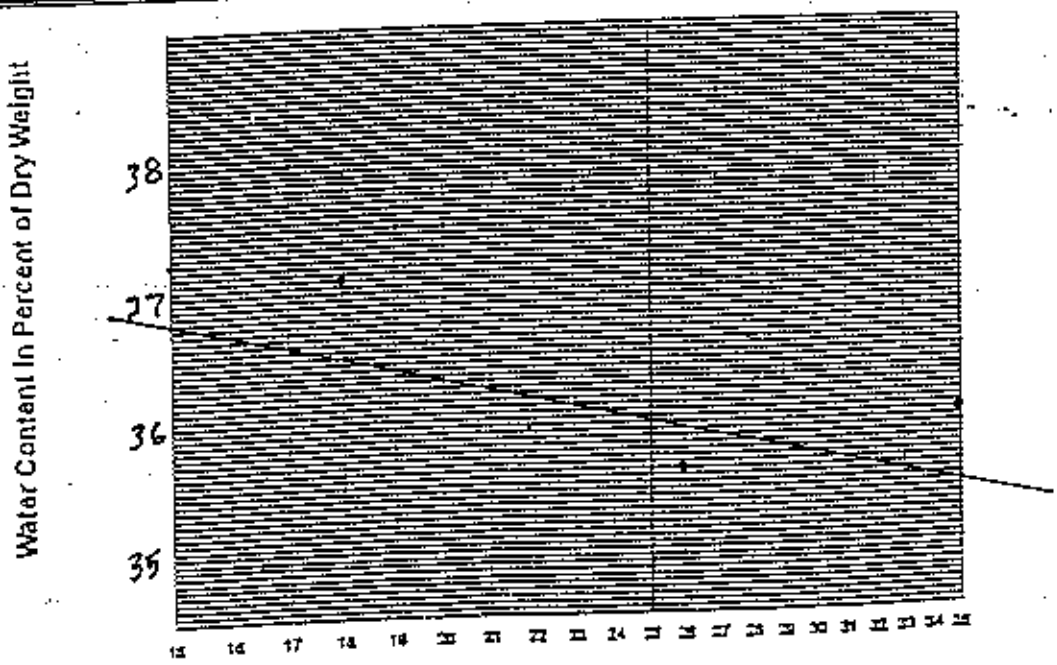
Design Specification: QUARRY BACKFILL CLASSIFICATION

Location of Test:

Northing: N/A Easting: N/A Elevation: N/A

		LIQUID LIMIT (LL)			PLASTIC LIMIT (PL)	
		LL	LL	LL	PL	PL
Number of Blows:		18	26	35		
Container Number:		11	10	12	46	23
Weight of Wet Sample and Tare:	.01	44.31 g.	44.71 g.	42.17 g.	34.55 g.	34.77 g.
Weight of Dry Sample and Tare:	.01	40.62 g.	41.23 g.	40.03 g.	33.50 g.	33.72 g.
Weight of Water:	.01	3.69 g.	3.48 g.	2.14 g.	1.05 g.	1.05 g.
Weight of Tare:	.01	30.68 g.	31.45 g.	31.30 g.	28.43 g.	28.74 g.
Weight of Dry Sample:	.01	9.94 g.	9.78 g.	8.73 g.	5.07 g.	4.98 g.
Water Content:	.1	37.1 %	35.6 %	36.0 %	20.7 %	21.1 %

FLOW CURVE



PLASTIC LIMIT (AVERAGE): 21 %

LIQUID LIMIT: 36 %

PLASTICITY INDEX: (LL - PL) = PI 15 ~~25~~ % 22.99

Comments: LL to the nearest whole number @ 25 blow line, PL and PI nearest whole number.

Performed by [signature] Date 3-2-99

Reviewed by [signature] Date 3-2-99

Revision 2

Atterberg Limit Test

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

JOB: WSSRAP
Work Package: 513

GRADATION ANALYSIS
ASTM D422

Sample ID #: QRSB-60 8.4-10.4'

Performance Log No.: NA Test Number: QC-24-03-31-15

Materials Log No. QC-24-10-31-15

Location of Test: North: NA East: NA Elev.: NA

Soil Description: Quarry Backfill Specification: NA

Balance ID No.: SC-11 (Pass) Fail / N/A

Report %'s to the nearest whole number, except if the % passing the 75-µm (No. 200) sieve is less than 10%, it shall be reported to the nearest 0.1%.

Material Size	Required Percent Passing	Actual Percent Passing
#4		100%
#100		98%
#200	N A	95%
N A		N A
	Total Weight of Sample	35 lbs

Sieve Size	Retained Weight and Tare	Tare	Weight Retained	Initial Dry Weight	Percent Retained	Cumulative % Retained	Cumulative % Pass	Required
#4	1.42	0	1.42	500	0.3	0%	100%	
#100	7.23	0	7.23	500	1.4	2%	98%	
#200	14.56	0	14.56	500	2.9	5%	95%	N A
			N					
				A				

Comments: NA

Performed by: [signature] Date: 3-3-99

Reviewed by: [signature] Date: 3-3-99

Gradation Analysis Form
04-13-87

Revision 2

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

Job: WSSRAP
Work Package: PM5

ATTERBERG LIMIT TEST
ASTM D 4318

Sample ID # QRSB-60 8.4 - 10.4'

Log Information

Balance ID No.: SC-10 Test No.: QC - 26 - 06 - 31 - 10

Material Log No.: QC - 26 - 10 - 31 - 15 Material meets Low Perm Requirements: (Y) / N

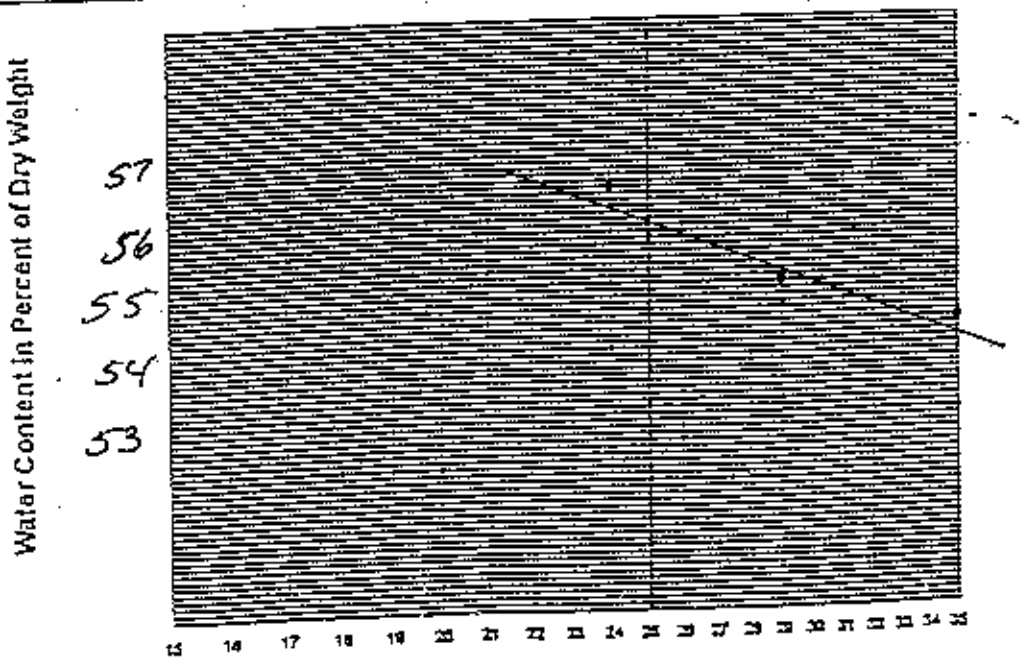
Design Specification: QUARRY BACKFILL CLASSIFICATION

Location of Test:

Northing: N/A Easting: N/A Elevation: N/A

		LIQUID LIMIT (LL)			PLASTIC LIMIT (PL)	
		LL	LL	LL	PL	PL
Number of Blows:		24	29	35	56	5
Container Number:		60	48	11	34.70 g.	37.74 g.
Weight of Wet Sample and Tare:	.01	39.63 g.	41.23 g.	45.56 g.	33.52 g.	36.54 g.
Weight of Dry Sample and Tare:	.01	35.29 g.	36.59 g.	40.33 g.	1.18 g.	1.20 g.
Weight of Water:	.01	4.34 g.	4.69 g.	5.23 g.	28.39 g.	31.34 g.
Weight of Tare:	.01	27.61 g.	28.07 g.	30.72 g.	5.13 g.	5.20 g.
Weight of Dry Sample:	.01	7.68 g.	8.52 g.	9.61 g.	23.0 %	23.1 %
Water Content:	.1	56.5 %	55.0 %	54.4 %		

FLOW CURVE



PLASTIC LIMIT (AVERAGE): 23 %

LIQUID LIMIT: 56 %

PLASTICITY INDEX: (LL - PL) = PI 33 %

Comments: LL to the nearest whole number @ 25 blow line. PL and PI nearest whole number.

Performed by [signature] Date 3-3-99

Reviewed by [signature] Date 3-3-99

Revision 2

Atterberg Limit Test
04-13-97

MK-Ferguson Company
Weldon Spring Site Remedial Action Project

TRANSMITTAL OF CONTRACT DELIVERABLE

Date: **August 12, 1999** Transmittal No.: **CD-0219-00**

Title of Document: **Completion Report For The Hydrogeological Field Studies In Support Of The Quarry Residual Operable Unit**

Doc. Num.: **803** Rev. No.: **0** Date of Document: **August 1999**

Purpose of Transmittal: Request for Department of Energy acceptance of contract deliverable.

In compliance with the Project Management Contract, MK-Ferguson Company hereby delivers the attached document to the U.S. Department of Energy, Weldon Spring Site Office. The document has been reviewed and approved by Project Management Contractor management.

The document will be considered accepted unless we receive written notification to the contrary within 30 days of the date of this transmittal.

Number of copies transmitted: 1

Douglas E. Steffen
Project Director

Printed in the United States of America. Available from the National Technical Information Service, NTIS, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161.

NTIS Price Codes - Printed Copy: A06
Microfiche: A01